JAN 26 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Advertisement, page 69, Jan. 5.

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MANNING, WARDLE AND COMPANY, LIMITED,
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See Illustrated Advertisement Page 79, Jan. 5.

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Steam and Electric Cranes
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LAND AND MARINE
YARROW BOILERS. 819

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See Full Page Advt., page 56, Jan. 5.

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HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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Pott, Cassels & Williamson,
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See half-page Advertisement, page 38, Dec. 22.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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British Empire Exhibition (1924).

SHIPBUILDING, MARINE, MECHANICAL & GENERAL ENGINEERING SECTION.

FIRST ALLOTMENT OF SPACE.

The first allotment of space to intending exhibitors in the above Section, will be made by The British Engineers' Association Exhibition Committee on

THURSDAY, FEBRUARY 1st, 1923.

Applications for space to be considered at this meeting must be delivered at the offices of

THE BRITISH ENGINEERS' ASSOCIATION (INCORPORATED),

not later than

SATURDAY, JANUARY 27th, 1923.

Full particulars and forms of application can be obtained at the offices of The British Engineers' Association.

D. A. BREMNER,
Director.

33, Victoria Street,
London, S.W. 1.

X 306

UNIVERSITY OF LONDON.

Notice is Hereby Given that

the Senate will proceed to elect EXTERNAL EXAMINERS for the Examinations above Matriculation as follows. Examiners are normally required to act in all Examinations in which the subject is included.

For the Calendar Year 1923.
Engineering, Civil and Mechanical (Two).
Metallurgy and Assaying.
Mining and Mine Surveying.

N.B.—Attention is drawn to the provision of Statute 1.4, whereby the Senate is required, if practicable, to appoint at least one Examiner who is not a Teacher of the University.

Application Form for Forms if more than one Examinership is applied for) and particulars of the remuneration and duties can be obtained from the External Registrar.

Candidates must send in their names to the External Registrar, Geo. F. Goodchild, M.A., B.Sc., with any attestation of their qualifications they may think desirable, on or before Monday, 22nd January, 1923. (Envelopes should be marked "Examinership.")

The Senate desire that no application of any kind be made to individual members.

If testimonials are submitted, one copy only of each is required. In no case should original testimonials be submitted. If more than one Examinership is applied for, a separate application, complete, with copy of testimonial, must be forwarded in respect of each Examinership. The appointments in Engineering will probably be made by the Senate towards the end of February. Applicants who desire that the results should be communicated to them are requested to enclose a stamped and addressed envelope with their applications.

E. C. PERRY,
Principal Officer.

University of London,
South Kensington, S.W. 7.
January, 1923. X 280

University of London, UNIVERSITY COLLEGE.

The following ENTRANCE SCHOLARSHIPS, available for Students entering the FACULTY OF ENGINEERING in October, 1923, each of the value of £40 a year, for three years, may be awarded on the results of an examination to be held in May, 1923:—

(I) Three Andrews Scholarships;
(II) A Goldsmid Scholarship.

Full particulars may be obtained on application to the undersigned.

WALTER W. SETON,
Secretary.

University College, London.
(Gower Street, W.C. 1.) X 298

Leeds University.

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SPECIAL COURSE OF EVENING LECTURES WILL BE GIVEN DURING JANUARY, FEBRUARY, AND MARCH, ON

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II. WATER GAS—BLUE and CARBURETTED. By Dr. A. Parker, D.Sc., F.I.C.
III. PRINCIPLES of GAS DISTRIBUTION. By Mr. Stephen Lacey, B.Sc.
IV. BY-PRODUCT COKING PROCESSES. By Mr. W. Greaves, F.I.C.
V. METALLURGY. By Mr. P. F. Summers, A.R.S.M.

The Laboratory will be open on Wednesday evenings for students desiring instruction in Fuel Calorimetry and Pyrometry.

For further information apply to
THE REGISTRAR, The University, Leeds. X 271

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Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of Engineering.

TENDERS.

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of STRUCTURAL STEELWORK.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Structural Steelwork," must be left with the undersigned not later than Twelve Noon on Tuesday, the 30th January, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director,

91, Petty France, S.W. 1.
5th January, 1923. X 297

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for Morwell Power Scheme.

Copies of Tender Form and Specification may be obtained or inspected upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.
Specification No. 23/8—
TRANSFORMERS.

Charge:—5s. for first two copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third, or any further copies may be obtained on payment of 2s. 6d. per copy, not returnable.

Preliminary Deposit:—A Preliminary Deposit of 1% of total Tender Price is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest Tender.

Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned, not in Melbourne, not later than Twelve Noon on the 31st March, 1923.

R. LIDDELOW,
Secretary. X 201

LIVERPOOL CORPORATION WATERWORKS.

VYRNWY SUPPLY.

NEW FILTER BEDS, OSWESTRY.

The WATER COMMITTEE of the Liverpool Corporation are prepared to receive

Tenders for the Construction

and Satisfactory COMPLETION of THREE FILTER BEDS and other ancillary Works, situated at Oswestry, in the County of Salop.

The Plans may be inspected and Copies of the Specification and Forms of Tender obtained at the Water Engineer's Office, Alexandra Buildings, 55, Dale Street, Liverpool, upon payment of the sum of Five Guineas, which amount will be returned upon receipt of a *bona fide* Tender.

Tenders, endorsed "Tender for Filter Beds," are to be sent through the post, in a sealed envelope, to the Town Clerk's Office, Municipal Buildings, Liverpool, addressed to the Chairman of the Water Committee, so as to be delivered not later than 12 o'clock Noon on Tuesday, 23rd January, 1923.

The Water Committee do not bind themselves to accept the lowest or any other Tender.

WALTER MOON,
Town Clerk.

Municipal Buildings,
Liverpool.
3rd January, 1923. X 241

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply of RAILWAY CARRIAGES.

Forms of Tender may be obtained from the Director-General, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than TWO o'clock p.m. on Tuesday, the 20th February, 1923.

T. RYAN,
Director-General.
X 289

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 26th January,

Tenders for the Supply of PIG IRON.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices, 91, Petty France,
Westminster, S.W. 1.
10th January, 1923. X 338

SEVENOAKS UNION.

GUARDIANS' INSTITUTION AT SUNDRIDGE, SEVENOAKS, KENT.

The Guardians of the Poor of the Sevenoaks Union invite

Tenders for the following

items of PLANT:—
ONE—GAS-FIRED BOILER with feed pump and accessories to Specification R.S.I. No. 11.
ONE—SMALL GAS ENGINE with accessories to Specification R.S.I. No. 12.
ONE—SMALL WATER-SOFTENING PLANT with main storage tank to Specification R.S.I. No. 13.

The work includes the supply of the plants and their erection on site at Sundridge, Kent.

Copies of the Specification Nos. 11, 12 & 13 can be obtained from the undersigned at Bank Chambers, High Street, Sevenoaks, Kent, on payment of a deposit of One Guinea for each Specification, which will be returned as soon as the Contract is let, provided that the Tender submitted is *bona fide* and complete. A duplicate copy of Specification Nos. 11, 12 or 13 will be supplied to Tenderers on a payment of Half a Guinea each, which amount will not be returnable.

Tenders, sealed and clearly endorsed on the outside, must be sent in complete with the accompanying drawings and particulars to the undersigned on or before Noon of Tuesday, the 6th February, 1923.

The Guardians do not undertake to accept the lowest or any Tender.

By order,
F. H. VIBERT,
Clerk,

Bank Chambers, Sevenoaks,
9th January, 1923. X 318

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification may be obtained or inspected upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.
Specification No. 23/7—
MOTORS, STARTERS and ISOLATING SWITCHES.

Charge:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third, or any further copies will be supplied for the sum of 10s. 6d. each, not returnable.

Preliminary Deposit:—A Preliminary Deposit of £40 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned in Melbourne, not later than Noon on March 15th, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne,
Australia. X 309

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following PLANT for the Morwell Power Scheme.

Copies of Tender Form and Specification may be inspected or obtained upon application to:—
THE AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.
Specification No. 23/9—
TRANSFORMERS and SPARES.

Charge.—10s. for first two copies of Tender Form, Specification and Contract Conditions complete.

This charge will be returned on receipt of a *bona fide* Tender.

A third, or any further copies may be obtained on payment of 5s. per copy, not returnable.

Preliminary Deposit.—A Preliminary Deposit of £10 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned in Melbourne, not later than Noon on April 28th, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne,
Australia. X 308

HIGH CARLEY SANATORIUM, near ULVERSTON.

FOR SALE, VERTICAL BOILER.

Offers are Required for a

Vertical BOILER, size 10 ft. 6 in. by 3 ft. 6 in., working pressure insured at 70 lbs. to sq. inch.

It will be necessary to take down a portion of two walls in order to admit of the removal of the boiler, and any offers should include the taking down and reinstatement of the brickwork, etc. The boiler can be seen on application to the Medical Superintendent.—Offers to be sent in to Dr. G. LISSANT COX, Central Tuberculosis Officer, County Offices, Preston. X 243

GREAT NORTHERN RAILWAY (IRELAND).

PERMANENT WAY MATERIALS.

The Directors are prepared to receive

Tenders for the Supply of:—

BULL-HEAD RAILS,
FLAT-BOTTOM RAILS, and
FISHPLATES,
of British Standard Sections; also
CAST-IRON CHAIRS and FASTENINGS.

Specifications, Drawings, and Forms of Tender can be obtained from the Secretary.

Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover, endorsed "Tender for Rails, &c.," not later than Ten a.m. on Friday, 2nd February, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin.
10th January, 1923. X 337

WEST HAM UNION.

TO HEATING AND HOT WATER ENGINEERS.

The Guardians purpose having carried out the

Installation of a Vacuum

STEAM HEATING AND HOT WATER PLANT to the FOREST GATE SICK HOME, FOREST LANE, E. 7.

Persons and Firms desirous of Tendering for the work, should, on or before the 17th day of January, 1923, forward to the undersigned their names and addresses, together with a deposit of £2 2s., which will be returned upon receipt of a *bona fide* Tender. A copy of the Drawings and Specification prepared by the Architect to the Guardians, Mr. F. J. Sturdy, F.R.I.B.A., of 115, Moorgate, E.C. 2, and Mr. G. W. Martin, M.I.Mech.E., of Sentinel House, Southampton Row, W.C. 1, can be seen at these offices on and after the above mentioned date and Tenders must be delivered before Ten a.m. on the 8th February, 1923.

THOMAS SMITH,
Clerk to the Guardians.

Union Offices,
Leytonstone, E. 11.
9th January, 1923. X 339

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—
CARRIAGE UNDERFRAMES with Four Wheel Bogies.

Fee for Specification, 10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Underframes," not later than Eleven o'clock a.m., on Tuesday, the 23rd January, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 10th January, 1923. X 336

METROPOLITAN WATER BOARD.

TENDERS FOR THE MANUFACTURE, DELIVERY AND FIXING OF FIVE LANCASHIRE BOILERS, ETC., AT THE SURBITON PUMPING STATION, SURREY.

The Metropolitan Water Board invite

Tenders for the Manufacture,

DELIVERY and FIXING of FIVE LANCASHIRE BOILERS, SUPERHEATERS, ECONOMISER, PIPING, FEED PUMPS, etc., at their Surbiton Pumping Station.

Forms of Tender, Conditions of Contract, Specification and Drawings may be inspected without payment of fee at the Office of the Board, Chief Engineer's Department, Room 182, 173, Rosebery Avenue, Clerkenwell, E.C. 1, on and after Saturday, 13th January, 1923.

Contractors desirous of tendering may obtain the necessary documents from Mr. Henry E. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of Three Guineas, which sum must be deposited with the Accountant to the Board, and will be refunded on receipt of a *bona fide* Tender, together with all incidental papers.

Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon).

Cheques must be made payable to the "Metropolitan Water Board," and not to individuals.

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for Boilers, Surbiton," must be delivered at the Offices of the Board not later than Ten a.m. on Monday, 5th February, 1923.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Acting Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
6th January, 1923. X 301

INDICATORS FOR HIGH-SPEED ENGINES.

To those who are familiar only with the pencil indicator, it would appear to be a comparatively simple matter to modify the design in order to render it suitable for high-speed engines, but a consideration of the principles on which the design is based shows that this is not the case. In any mechanism that contains reciprocating elements, difficulties due to the inertia of the parts must arise as the speed of operation is raised, and in the case of the instrument under consideration the inertia forces become sufficiently great to create a disturbing influence at about 350 r.p.m. Given that the amplitude is fixed, the disturbance due to inertia forces can only be dealt with in one of two ways, either by the introduction of counterbalancing forces, or by reducing the weight of the reciprocating parts. In the case of the pencil indicator, counterbalancing forces can only be introduced by stiffening the spring, and as this at once reduces the amplitude, it results in a low diagram which is difficult to measure accurately. The designer who is aiming at modifying the instrument for high-speed work must therefore seek to reduce the weight of the reciprocating parts.

So long as the characteristic features of the pencil indicator are retained, there is a fairly definite limit beyond which the weight cannot be reduced, and a practical limit of speed is reached in the neighbourhood of 600 r.p.m. As many internal-combustion engines normally run at speeds of 2,000 r.p.m., or even more, the designer of a suitable indicator for such engines is thus forced to abandon one or more of the characteristic features of the pencil indicator, or alternatively, to seek an entirely new solution of the problem. In the former class, the various investigators who have sought to develop the optical indicator may be included, together with those who have worked on the micro-indicator, while the latter group includes the experimenters in the different types of electrical indicator.

With the pencil indicator, a permanent diagram of convenient size for direct measurement can be obtained in a few seconds, but this feature is sacrificed in the higher speed types. With the optical indicator, it is necessary to photograph the diagram to make the record permanent, while with the micro-indicator, the diagram is too small to be measured directly. Both these types produce the conventional diagram showing pressure variations over the complete cycle, but in the case of the electrical indicator the record is given in a form which necessitates re-plotting if a diagram of this type is required. With the two former instruments, a record of a single cycle can be obtained, but the diagram produced by the electrical indicator represents the average pressures over a number of cycles. This point is not of any great importance, because a single cycle diagram is rarely required in practice, in fact, successive cycles frequently show such wide pressure variations that a single cycle may be actually misleading.

The optical indicator is the oldest of the high-speed types, and it offers a very attractive field for investigation. Among the better-known indicators of this type may be mentioned the Hopkinson, Watson and Burstall, in England, and the Midgley, in America. Practically all these designs are based on the earlier work of Schultz, Charpentier and Perry. It is doubtful whether any of these designs can be said to be entirely satisfactory, and this in itself offers some indication of the difficulty of finding a satisfactory solution of the problems involved in the design. The difficulties that have to be oversome by the designer of this class of instrument only become apparent to those who have been closely associated with the development of any particular type, and it will be of interest to consider them in some detail.

As in the case of the pencil indicator, the mechanism consists essentially of two elements, comprising one which imparts a movement to the recording mechanism to register the pressure in the engine cylinder, and a second which imparts a movement reproducing the motion of the piston in the cylinder. These two elements are common to both the pencil and the optical indicator, the essential difference between the two being in the nature of the recording mechanism. In the optical type, a ray of light is projected from a suitable source, such as an arc lamp, on to a small convex mirror, from which it is reflected and brought to a focus on a ground-glass screen. The entire apparatus with the exception of the light source, is enclosed in a box or camera, and a permanent record of the diagram can be obtained by substituting a photographic plate for the screen. A convenient size of plate is 5 in. by 4 in., giving a diagram of approximately the same size as an ordinary pencil indicator. To obtain a record of any desired number of cycles, a variable speed shutter may be placed between the light source and the camera.

The convex mirror is mounted on a small carriage, and by means of a suitable mechanism this carriage is tilted an amount proportional to the pressure in the cylinder of the engine under test. This movement produces a linear displacement of the point of light on the screen, the amount of displacement corresponding to the pressure. If at the same time the point of light can be given a second linear motion at right angles to the first, and corresponding to the piston displacement, it will trace out the indicator diagram, the motion being so rapid that the eye will receive the impression of a continuous line over the whole cycle.

The second displacement, corresponding to the piston position, may be obtained either by a rotation of the mirror carriage about the axis of the mirror, or by introducing a second flat mirror between the convex mirror and the screen, and giving this a tilt in a direction perpendicular to that due to the movement of the convex mirror. By this means the inertia of the pencil, the pencil carrier, and the parallel motion is eliminated. As a beam of light offers a ready means by which the movement of the piston can be magnified, the actual movement of the reciprocating mechanism can be greatly reduced, and as at the same time these parts can be made very much lighter, it would be anticipated that the instrument could be run at a higher speed without the disturbing influences of the inertia forces being apparent.

It will be clear, however, that the improvement is only one of degree, and that a new speed of operation will be reached at which these forces again become dominant. It has been found in practice that this speed is in the neighbourhood of 2,000 r.p.m., and that for speeds higher than this the inertia forces again become very difficult to control. It is just possible that by a very careful design of the reciprocating elements, the practical limit of operation may be raised to a point which is sufficiently high to meet the requirements of practically all the engines at present on the market, but one or two special engines have been made recently of which it may be said that they run at such a speed that they could not be indicated with any existing optical indicator.

Turning now to the mechanism of the instrument in greater detail, and still confining our attention to the pressure element, it will be found that the indicators which have been developed fall into two groups, in one of which the cylinder and piston of the pencil indicator are retained, and in the other this mechanism has been replaced by a flexible diaphragm such as is used in an arenoid barometer. The advantages of the latter system are obvious, not only are the possibilities of both gas leakage and piston friction eliminated, but the diaphragm will have a much smaller mass than the corresponding piston. The difficulties encountered in the manufacture of a suitable diaphragm have proved so great, however, that the majority of experimenters have preferred the piston. So far as we know, the only optical indicator employing the diaphragm is the Watson, although Midgely makes use of a similar device in the electrical indicator.

The conditions that have to be fulfilled by the diaphragm are very stringent. It must be of such a form that it gives a linear scale, that is to say equal differences in pressure should produce equal deflections, it must be sufficiently stiff not to take a permanent set under a pressure amounting to approximately half a ton, and it must stand up to impacts of this magnitude repeated at intervals of from one-eighth to one-twentieth of a second for several hours. The difficulty of making a diaphragm capable of giving this service has been regarded as prohibitive by most investigators, but diaphragms have been made for the Watson indicator which have stood up on an indicator applied to an aero engine for over 40 hours, and are still in use. This engine runs at 1,200 r.p.m., so that these diaphragms have been subject to some 1,500,000 impacts repeated at intervals of one-tenth of a second. It therefore appears that this difficulty has been overcome, at any rate at moderate speeds. These diaphrams do not give an exact linear scale, but this point is not of any great importance, as it simply means that the diagrams must be measured up by means of a suitable pressure scale, using the ten ordinates rule instead of a planimeter for obtaining the area.

It does not appear possible to calculate out of the theoretical shape of the corrugations in the diaphragm to produce a linear deflection scale, and the question resolves itself into a determination of the correct shape by trial and error. This is an exceedingly tedious and expensive business, as each shape involves the manufacture of a suitable die, and the point may well be left until some of the other difficulties incidental to optical indicators have been successfully overcome. The departure from the linear scale is very small in the case of the diaphragms used by Watson, the diagrams being quite normal in appearance.

The movement of the piston or diaphragm due to an alteration in pressure is transferred by means of a suitable mechanism to the carriage which carries the pressure mirror. For the reasons already given, this must be as light as possible, and it is at this point that extreme care must be taken with the design if the inertia forces are not to become troublesome at high speeds. It must be borne in mind that the return motion of the carriage after a deflection is effected by means of a spring, and that it does not appear possible to make this return positive. In the case of the pencil indicator, it is well known that trouble may be experienced at the higher speeds by the vibrations of the spring itself, and that, given that the reciprocating mechanism has been made as light as possible, the superimposed waves produced in the diagram from this cause can only be obviated by the use of a stiffer spring having a higher natural period of vibration. Exactly the same problem has to be dealt with in the case of the optical indicator, although, as already explained, the reciprocating element is much lighter, and therefore the difficulty manifests itself at a much higher speed of operation. The two cases are not strictly parallel, because any increase in the stiffness of the spring in the pencil indicator reduces the height of the diagram, but this does not follow in the case of the optical indicator.

The magnification of the movement is theoretically unlimited with a ray of light, but a practical limit is introduced by the convenient size of the apparatus, the length of the camera becoming inconvenient if it exceeds about 16 in. If, say, a 4 in. by 5 in. plate is used to record the diagram, this gives an actual movement of the piston or diaphragm of about 0·03 in. It will be appreciated that with such a small actual movement of the mirror carriage, a very small degree of slackness in the mounting would lead to errors which would destroy the accuracy of the diagram, and for this reason, an ordinary journal-bearing is not used. Instead of this, the carriage is either mounted on a pin point and knife edge, or, alternatively, on a strip of steel which is clamped firmly at the end, the necessary rotation of the mirror being imparted by the flexure of the strip. The former method, for example, is employed in the Watson indicator, and the latter in the Burstall. A third alternative consists in mounting the carriage between pin points, as in the Hopkinson. As it is necessary to mount the indicator close to the engine under test, it is difficult to avoid the possibility of the vibrations of the engine being imparted to the indicator, and it is therefore desirable that the latter should not be detrimentally affected by such vibrations. In the pin point and knife-edge type of mounting, for example, the accuracy of the diagram may be affected by waves being produced as a result of the carriage jumping on its supports owing to this vibration, and very similar trouble is sometimes experiemced with the Hopkinson type of mounting owing to vibration of the spring supports which carry the mirror carriage. This

results in an intermittent slackness in the bearing points, which again give rise to waves in the diagram.

Dr. Dickinson has pointed out that when the indicator is mounted directly on the cylinder, and the head of the latter is relatively thin, as in an aero-engine, the head itself may flex under the sudden stress of a detonation of the fuel. The result will be that the supports carrying the carriage will themselves acquire an enormously rapid motion relative to the piston or diaphragm, since the latter must be of appreciable mass. This effect is likely to be much more pronounced in the case of the piston, as the piston and piston rod are much heavier than the moving portion of the diaphragm.

To minimise these effects, the indicator should be mounted on a framework which is entirely separate from the engine supports, and this framework may with advantage be braced to some rigid body, such as the walls of the test-house. The only connection between the engine and indicator will then be by means of a small bore tube, which should have an expansion bend to increase its flexibility. This tube must be made as short as possible, as otherwise an appreciable lag is likely to occur between the pressure in the cylinder and that in the gas in contact with the piston or diaphragm. The cooling of such a tube offers some difficulty, as anything in the way of a water jacket will tend to make it too rigid, but a satisfactory, if somewhat crude, method of effecting this cooling is to spray the pipe with a fine jet of water.

Turning now to the second element, which is designed to impart a movement to the point of light on the screen reproducing the motion of the piston in the engine cylinder, it has already been stated that this may be performed either by rotating the carriage carrying the concave mirror, or, alternatively, by introducing a second mirror to deflect the light ray at right angles to its first path. This problem offers no great difficulty, because if the return motion is effected by means of a spring, this may be made as stiff as desired. The outward motion is positive, and increasing the stiffness of the spring cannot affect it for this reason. It is evidently desirable, however, that the reciprocating elements in this case also should be made as light as possible, as otherwise the connecting mechanism will have to be made very rigid if it is not to flex under the stresses set up in it by the inertia forces of the indicator mechanism.

As all the reciprocating portions of a high-speed engine are usually totally enclosed, it is rarely practicable to obtain the indicator movement from a reciprocating point on the engine, as is usually done in the case of the pencil indicator. It thus becomes necessary to convert the rotary motion of some such element as the crankshaft back to reciprocating motion by means of a cam or eccentric, and it is an advantage if this function is embodied in the mechanism of the indicator itself, rather than having to make a rig on each individual engine for this purpose, which is the usual practice with the pencil indicator.

The Watson indicator offers a typical illustration of the manner in which this may be carried out. The indicator is of the two-mirror type, and a shaft mounted on the framework of the instrument carries an eccentric, the motion of the latter being utilised to impart an oscillation to the second, or stroke, mirror. The drive to the indicator can readily be arranged by mounting a sprocket on the crankshaft extension, or on the magneto or pump shaft, and driving from this to a second sprocket mounted on a shaft coupled to the indicator eccentric. The crank-connecting rod ratio varies in different engines, and this alters the relative position of the piston in its stroke for any given crank angle. As the spot of light on the screen is required to reproduce the true piston displacement at any instant, the ratio of the eccentric to the eccentric rod must be the same as the crank-connecting rod ratio of the engine under test. The eccentric rod of the indicator must therefore be adjustable for length.

Although the conception of the micro-indicator is by no means new, special attention has recently been devoted to it. The instrument designed by Mr. Collins was illustrated in our issue of June 9 last, page 716, and it is not necessary to describe the type in further detail. It is interesting to note that in this form of instrument the inertia forces introduced at high speeds are minimised by making the whole instrument very small.

A brief reference may be made to the electrical indicator, and the following particulars are taken from information published by the American Bureau of Standards. In this instrument the first, or pressure element, consists of a flat steel diaphragm about $\frac{3}{4}$-in. in diameter and 0·002 in. thick. This is subject on one side to the pressure in the engine cylinder, and on the other to a constant pressure of any desired and controllable value, supplied by a compressed-air system when it is desired to register pressures above atmospheric, and by a vacuum system when pressures lower than atmospheric are to be dealt with. The diaphragm is fitted with a contact point, so that when it moves it completes an electrical circuit, which may be utilised to notify the movement in any desired way. If a commutator is inserted in the electrical circuit, so that the latter can only be completed at a particular crankshaft position, the point in the cycle at which the movement of the disc occurs is located. The method of using the instrument is to set the commutator at a particular point, and then to gradually lower the controllable pressure until an indication is given that the disc has moved across. By repeating this procedure for a number of points on the cycle, sufficient information is obtained to plot a pressure variation curve over any part or the whole of the cycle.

In this case the reciprocating element is reduced to the small diaphragm mentioned, and it would be anticiapted that inertia effects would be reduced so considerably that they would have no effect on the action of the instrument. Satisfactory results have been recorded at 3,000 r.p.m., and there appears to be no reason why speeds of 10,000 r.p.m. could not be dealt with, if desired. The instrument could readily be modified to plot the pressure curve automatically. One of the great advantages of this type of instrument lies in the fact that it may be installed with the registering mechanism at any desired distance from the engine.

THE MANUFACTURE OF SPIRAL BEVEL GEARS.

WHILE in the matter of durability, strength and efficiency, a carefully designed bevel drive for a motor car back axle leaves but little to be desired, it has the drawback which is of considerable importance in connection with pleasure cars of being noisy in operation. This feature is particularly noticeable when the gear has become worn, and when the size of the gear and the number of teeth employed for a given gear ratio have been reduced in order to decrease the amount of unsprung weight. It is probably due to the absence of this drawback from spiral-bevel gears, in conjunction with improved facilities for the production of them, that they have been so largely adopted by motor car manufacturers for back axle drives. The smooth and quiet operation which characterises the spiral-bevel drive arises from the fact that, when properly designed and cut, a continuous pitch-line contact is obtained with a number of teeth in simultaneous engagement, the action resembling that of an ordinary worm and worm wheel, except that the sliding motion, and the consequent friction and wear, are much less.

Although the advantages of spiral bevel gears were early recognised, their development was long hampered by the lack of suitable machines for producing them accurately and at a moderate cost. Rapid strides have, however, been made since the production of the Gleason spiral gear generator in 1913, so that they are now employed for the back-axle drives of probably some 90 per cent. of the pleasure cars manufactured at the present time, and are being used to a large and increasing extent in machine tools, sewing machines, &c.

During the war the manufacture of pleasure cars in this country, of course, practically ceased, so that the spiral bevel drive was but little known here at the time of the armistice, although it was widely used in the United States. Messrs. E.N.V. Motors Limited, however, were so convinced of its superiority for this particular application that they decided, early in 1919, to install the necessary plant for the production of the gears on a large scale in their works at Hythe-road, Willesden Junction, N.W.10. The works, which we propose to describe in the present article, have been in existence for some years, having been engaged in the production of straight tooth bevel gears, gear boxes, camshafts, &c., but although these products are still manufactured, the works are now mainly devoted to the production of spiral-bevel gears. The capacity of the plant, it may be mentioned, is fully equal to the largest demands likely to be made on it, and provision has been made for future extension when necessary. The gears are supplied to motor car manufacturers and others whose individual requirements do not justify them in putting down the plant or employing the specialists necessary for their production.

The main shops are situated in a single-storey brick building having a saw-tooth roof and divided into bays with a central line of shafting in each, driving the countershafts situated over the tools on both sides. In one of the bays, 11 Gleason roughing machines are situated, while the finishing machines, of which 20 are employed, are conveniently grouped in the other bays. The finishing machines are all of the 15-in. size, except one, which is an 8-in. machine.

The material used for E.N.V. gears and pinions is a nickel-chrome case-hardening steel specially made for the purpose and purchased in the form of forged blanks. Accurate turning of the blanks is, of course, a matter of considerable importance, and this work is carried out on lathes constructed by the American Tool Works Company, of Cincinnati, U.S.A., or other standard makers. In some cases, however, machined blanks are supplied by motor car manufacturers, who may also carry out the heat treatment themselves after the teeth have been cut at the E.N.V. Works, but in general it is obviously preferable for one concern to have undivided responsibility for the whole of the manufacturing processes that may affect the efficiency of the final product. For this reason, the works we are referring to have been fully equipped for the heat treatment of the gears, as well as with plant for grinding the shafts and machining the casings, so that completely finished back axles and other components can be produced.

It should first be explained that in Gleason spiral bevels the teeth are curved in the arc of a circle, the use of the circular curve in place of the theoretical spiral rendering rapid production possible, and also permitting a wider range of adjustment in assembly and operation. Although the finishing machine is capable of generating the teeth from the solid blank, its output is greatly augmented by first removing the bulk of the metal on a separate roughing machine; the use of the latter, however, is only justified when a fairly large production is required. The roughing machines are of simple and rigid construction, and are fully automatic and universal within their range, cutting either right-hand or left-hand spirals, but have no generating action. The cutters used, which will be described more fully later in connection with the finishing machine, are similar to a face mill with straight-sided inserted teeth, and are driven in a single reduction from the pulley shaft by means of a pinion meshing with an internal gear on the cutter spindle; a flywheel is mounted on the latter to render the cutting action smooth and even. The feed, which is a plain depth feed only, is obtained by means of a cam on the cutter spindle sleeve operated by a worm wheel drive, cams of different throws being employed to suit the various pitches used. The work is mounted on a spindle carried by a head which can be set to the required root angle, and is provided with indexing motion only. The indexing motion is operated by means of a cam, and is controlled by a notched dial which is special for each number of teeth to be cut. A clamp on the front bearing of the work head automatically holds the spindle rigidly during the cutting operation and releases it for indexing. The work which can be handled on this machine covers practically the whole range of requirements in motor car manufacture. Gears can be roughed out with pitch angles ranging from 29 deg. 45 minutes to 82 deg. 53 minutes, and with gear ratios up to 8 to 1. With this ratio, the largest pitch diameter that can be accommodated is

15 in. The cutter speed is 106 ft. per minute, and the cutting time per tooth ranges from 11 seconds to 39 seconds. About 5 h.p. is required to drive the machine. For roughing pinions a similar machine is employed, the main distinction being the provision of a limited generating motion used in connection with the depth feed. This is necessary, because the sharp curvature of the pinion pitch-cone surface and the great variation of the final tooth profile from the shape of the cutter would leave a large quantity of stock to be removed by the finishing cut if a plain roughing cut were employed without generating action. The cutter speed used in the pinion rougher is the same as that used in the gear rougher, viz., 106 ft. per minute, and the time occupied in cutting a tooth ranges from 18 seconds to 1 minute 12 seconds.

The finishing machines are, of course, the most interesting feature of the plant, and one of these is illustrated from different points of view, and with most of the gear casings removed, in Figs. 1 to 4, annexed. Before describing the somewhat complicated motions of the machine, it would, perhaps, be as well to indicate the general principles involved in its design. The machine is, of course, of the generating type, and the generating action is effected by causing the gear blank and the rotating cutter to roll together in exactly the same manner as if the cutter blades were one of the teeth of a crown bevel. For this purpose, the work is rotated about its own axis, and, at the same time, the cutter axis is made to describe an arc of a circle so that those blades which are actually cutting at any particular moment also move in a circular path having a radius equal to that of a crown bevel gearing with the work. By a crown bevel is meant one having a cone-angle of 90 deg., such as could be used to connect two shafts the axes of which are in the same plane and have an angle greater than 90 deg. between them. A crown bevel, it may be remarked, has straight-sided teeth and bears the same relationship to the bevel system as a rack does to the spur system. In the machine with which we are now dealing, the relative speed of the rolling motion of the cutter and gear is the same as would hold between the gear being cut and a crown gear represented by the cutter, the blades of which are also straight-sided. As the rotating cutter rolls in conjunction with the gear blank, the blades remove all material which would interfere with the correct rolling action between the gear being cut and the imaginary crown gear, and in this way the correct tooth profile is produced. As each tooth is formed, the cutter rolls clear of the blank, and indexing motion turns the latter for the cutter to operate on the next tooth, the process being continued automatically until the wheel has been finished.

Two methods of finish cutting are employed, known, respectively, as the standard and spread-blade methods. The former is generally employed when only a moderate number of gears is required and involves the cutting of one side of all the teeth

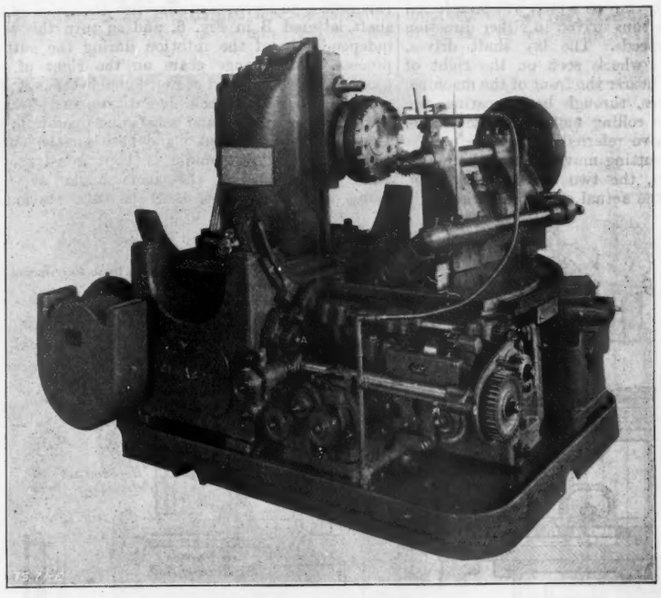


FIG. 1.

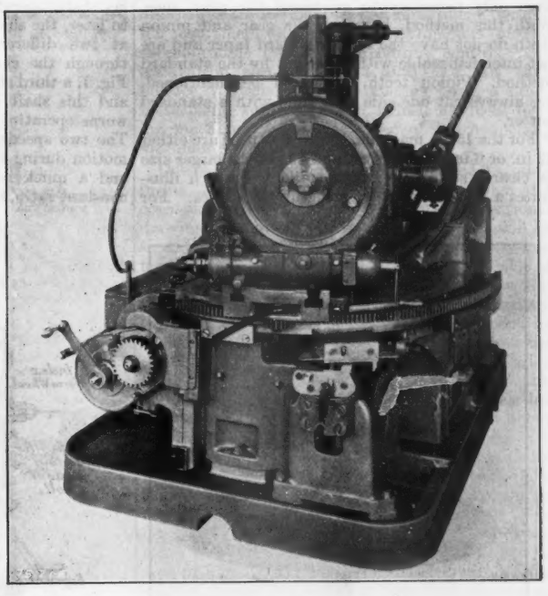


FIG. 2.

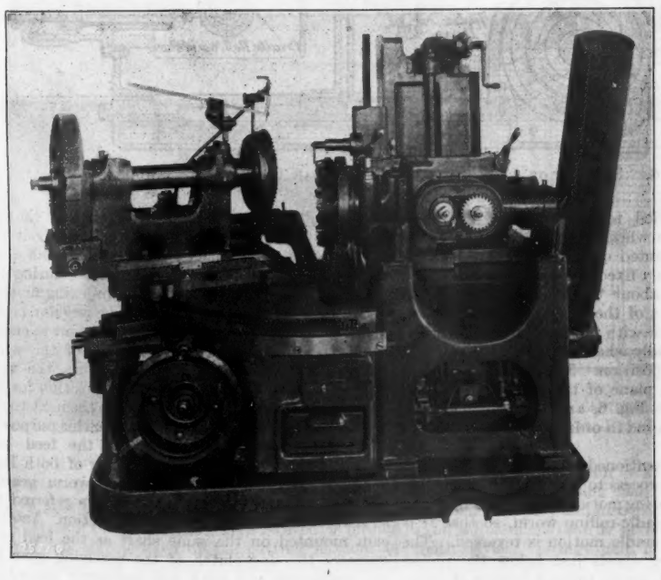


FIG. 3.

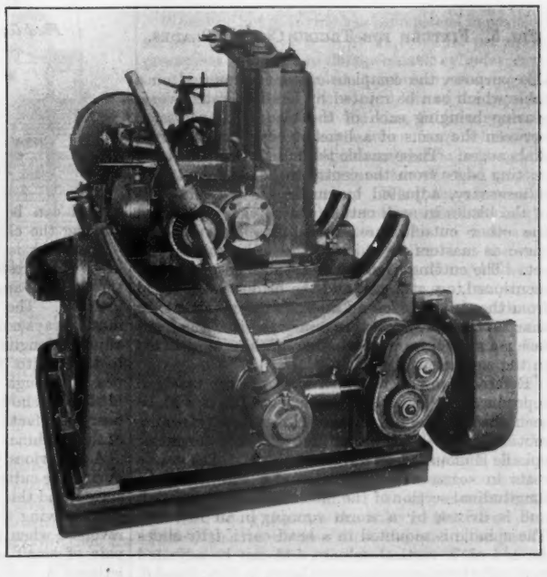


FIG. 4.

FIGS. 1 TO 4. SPIRAL BEVEL GEAR GENERATING MACHINE.

first, and afterwards altering the setting of the gear and cutter slightly for cutting the other side of all the teeth; both gear and pinion are cut in the same way and with the same cutter. For quantity production, the spread-blade method is more suitable since it effects a saving of some 40 per cent. of time in comparison with the standard method. In the spread-blade method, the alternate blades of the cutter are set at different radii so as to work on opposite sides of a tooth space simultaneously; it is thus only necessary to go round the gear once. With this method, however, the gear and pinion teeth do not have the same standard taper and are not interchangeable with those cut by the standard method. Pinion teeth, it should be mentioned, are always cut one side at a time with a standard cutter.

For the 15-in. machine, the cutters used are either 12 in. or 6 in. in diameter, and one of the larger size is clearly shown in Fig. 5, subjoined, which illustrates a fixture used for truing up the blades. For

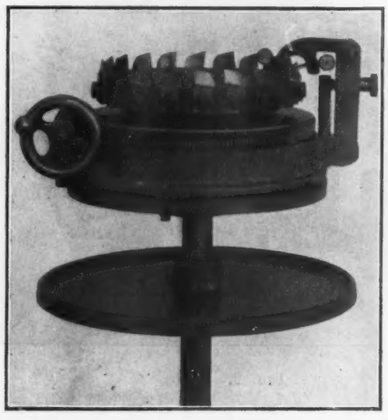


FIG. 5. FIXTURE FOR TRUING CUTTER BLADES.

this purpose, the complete cutter is mounted on a table which can be rotated by hand-operated worm gearing bringing each of the blades in succession between the arms of a bracket carrying a pair of dial gauges. These enable the radial distance of the cutting edges from the centre to be measured and, if necessary, adjusted by means of wedges. Two of the blades in each cutter, one cutting inside and the other outside, are non-adjustable and these serve as masters to which all the other blades are set. The cutting edges of the blades, as previously mentioned, are straight, and the blades are relieved from the cutting edge on a circular arc, so that, to sharpen them, it is only necessary to grind the front face; a special form of grinding machine is included in the equipment for this work.

Referring now to the illustrations of the machine reproduced in Figs. 1 to 4, on page 33, it will be seen that in order to obtain the necessary rolling motions between the cutter and the gear, the cutter spindle is mounted on a rocking cradle. The cradle rests in segmental "vee" grooves shown in the longitudinal section of the machine, Fig. 6, annexed, and is driven by a worm running in an oil bath. The spindle is mounted in a head carried by slides formed on a vertical column and can be adjusted vertically by means of a screw shown in Figs. 3 and 6, and locked in position. Horizontal adjustment for the column is also provided, as shown in Fig. 6. The cutter spindle is driven from the belt pulley, which runs at 500 r.p.m., through bevel gears and a swinging shaft best shown in Fig. 4. The swinging shaft drives a lay shaft on the cutter head and this drives the cutter spindle through bevel gearing shown in Fig. 6. The drive from the lay shaft to the cutter shaft is taken through change wheels shown in Fig. 3, and, by altering these change wheels, cutter speeds ranging from 36 ft. to 119 ft. per minute can be obtained.

All other motions of the machine are driven from a shaft running at right angles to the pulley shaft and driven from it through bevel gearing and change wheels, the latter being shown near the bottom right-hand corner of Fig. 4; these change wheels thus control all speeds except that of the cutter. The drive is transmitted through the pinion lettered A, in Fig. 1, to a second shaft situated just below the edge of the table, and this shaft carries near its outer end two spur gears, one of which meshes directly with a corresponding gear on a lay shaft, while the other drives the lay shaft through an intermediate pinion. By means of a dog clutch on the lay shaft, operated by means which will be referred to later, the shaft is thus driven in either direction at two different speeds. The lay shaft drives, through the change wheels seen on the right of Fig. 1, a third shaft nearer the front of the machine, and this shaft drives, through bevel gearing, the worm operating the rolling motion of the cradle. The two speeds, above referred to, provide a slow motion during the cutting movement of the cradle and a quick return, the two speeds being at a constant ratio, but the actual speeds and the angle

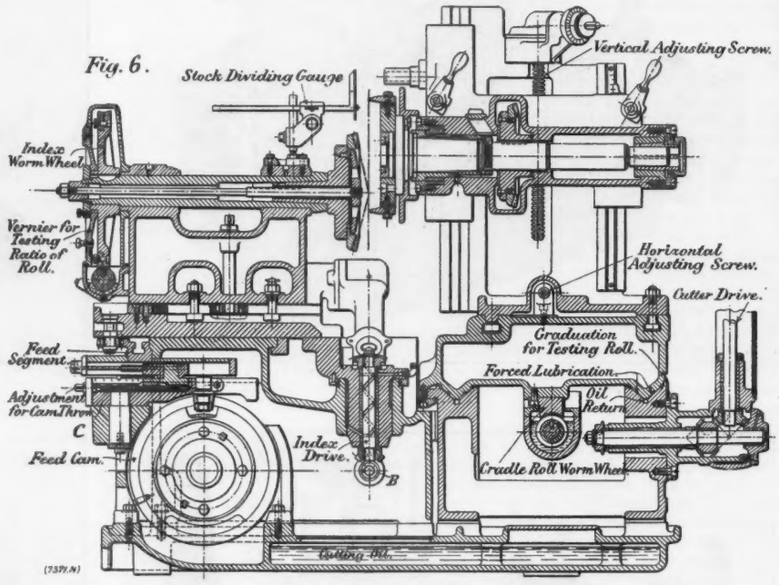


FIG. 6. SECTION OF 15-IN. SPIRAL BEVEL GEAR GENERATING MACHINE.

as rotates the work during the cutting process, but, of course, only comes into operation when the cutter and work are separated; it actually occurs at the end of the return stroke just before the work and cutter come again into contact for cutting the next tooth. For the indexing motion, a differential gear, operated from what we described above as the second shaft, is used. The bevel gear operating the differential is visible in Fig. 1, just behind the connection to the flexible oil pipe. The effect of this gear is to increase or diminish the speed of the shaft lettered B in Fig. 6, and so turn the work independently of the rotation during the cutting process. The change gears on the right of the group in the foreground of Fig. 1 enable the indexing motion to be varied for different numbers of teeth.

During the cutting and generating operation, the angle in the horizontal plane between the cutter spindle and work spindle is kept constant, its value depending on the cone angle of gear being cut. The work head is thus stationary of roll can be varied to suit different gears by altering the change wheels.

The work is mounted on a spindle carried by a head which rests on a fixed table and can be turned through an angle about the vertical axis of the machine. The apex of the pitch cone of the work must always coincide with this axis, and the work is adjusted longitudinally when setting up the machine to bring it to this position. The vertical axis also passes through the plane of the tips of the cutter blades, as shown in Fig. 6, and it is important to bear these facts in mind in order to follow the action of the machine.

As previously mentioned, the work is rotated during the cutting process to produce the generating action, and this rotating motion is obtained from the shaft driving the cradle-rolling worm, so that it is reversed when the cradle motion is reversed. The pair of small mitre wheels just below the pinion lettered A, in Fig. 1, drives through a train of gears, the shaft lettered B, in Fig. 6, and this drives a vertical shaft situated exactly in the axis of the machine. From this shaft, through a series of enclosed shafts and mitre wheels, a horizontal telescopic shaft on the side of the work head is driven, as will be gathered from Fig. 1, and this shaft drives the work spindle through a worm and worm wheel clearly shown in Fig. 6. It is, of course, necessary to alter the relationship between the roll of the work and the roll of the cutter to suit different gears, the relationship depending on the ratio of the number of teeth in the wheel to the number of teeth in the pinion. This is accomplished by changing the wheels in the gear train above referred to. The indexing motion is obtained by the same mechanism during this part of the operation, but at the end of the cutting roll it is swung round about the vertical axis of the machine through a small angle so as to separate the work and cutter during the return roll, and also to allow the indexing motion, above described, to take place. The angular movement, of course, need only be just sufficient to enable the cutter blades to clear the teeth of the wheel being cut. When this has been done, the work head is turned back to its original position for the cutting and generating operation on the next tooth.

The partial rotation of the head for this purpose is effected by mechanism operated by the feed cam shown in the left-hand bottom corner of both Figs. 3 and 6. The cam is driven by worm gearing operated from the second shaft above referred to, so that it runs always in the same direction. Another cam mounted on the same shaft as the feed cam operates the dog clutch of the reversing gear for the cradle roll and work roll previously described. In a groove formed in the cylindrical surface of the feed cam runs a roller mounted on the end of a rocking arm lettered "C" in Fig. 6, and this arm carries a sliding block, the distance of which from a the pin on which the arm rocks can be varied by means of a screw. Pivoted to the sliding block is a box-shaped casting which is clamped on to a quadrantal rack sliding in a groove formed in the edge of the fixed table of the machine. The work head can be clamped to this rack in any position by means of tee-headed bolts, one of which can be seen in Fig. 3. The form of the groove in the cam is such that the rocking arm is turned at the end of the cutting stroke, and the rack, and the work head with it, is consequently turned away from the

cutter through an angle which depends upon the distance of the sliding block from the pin of the rocking arm. By the same means the work head is returned to its original position at the end of the return motion of the work and cutter, and after the next tooth has been indexed.

Although the cam operating this mechanism is described on Fig. 6 as the feed cam, it must be pointed out that its object is merely to turn the head as above described so as to move the work into contact with or away from the blades of the cutter; there is no longitudinal feed of the work towards the cutter such as is employed on the

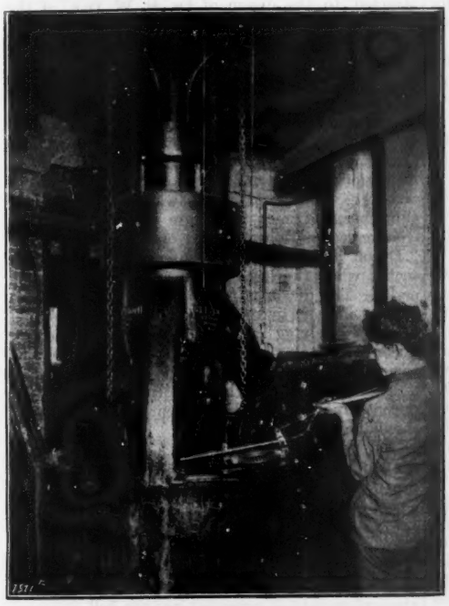


FIG. 7.

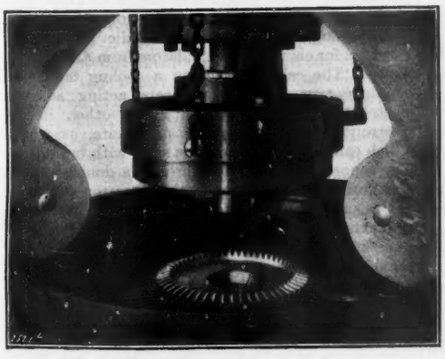
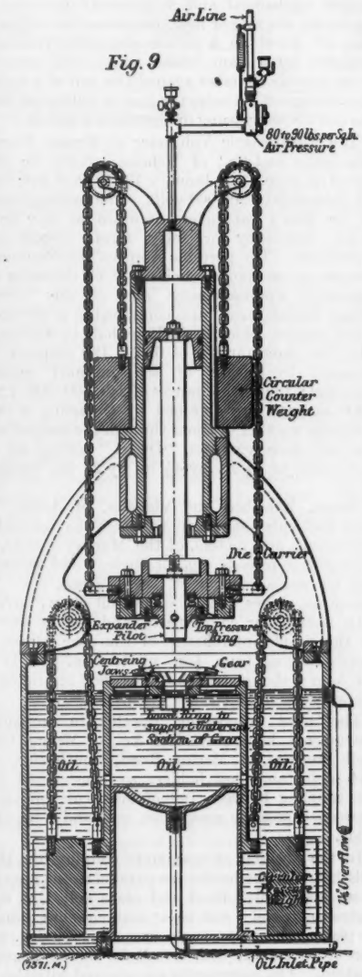


FIG. 8.

roughing machine. One side of a tooth (or both sides if a cutter of the spread-blade type be used) is formed completely during each of the cutting motions of the machine, the quantity of metal to be removed depending upon the form of the tooth left after the roughing process. The time occupied in cutting each tooth can, however, be varied by means of the change wheels shown on the right of Fig. 4, and ten changes can be obtained in this way giving cutting times ranging from 19 seconds to 1 minute 53 seconds per tooth. Gears up to 19¼ in. pitch diameter with a gear ratio of 8 : 1 can be cut on this machine, this range being sufficient to meet all usual requirements of the motor car industry.

After cutting, the gears are tested while still in the soft state to ascertain their running properties and also to check the setting-up of the cutting machines; five testing machines are installed for this purpose. In these machines there are two spindles placed at right angles, and the pinion is mounted on one of these spindles while the wheel is mounted on the other. The spindle carrying the pinion is driven by belt at 600 r.p.m., and an adjustable brake acts on the other spindle so that the load can be varied at will; the direction of rotation can also be reversed. The pair of gears is run on the machine for a few minutes, and the gears are afterwards examined to ascertain the markings where the contact between the teeth has taken place. When properly designed and mounted, the heaviest pressure occurs at the centre of the face of each tooth and eases off at each end, this feature allowing for a slight displacement of the gears under working conditions without impairing their efficiency and also giving a greater range of axial adjustment than is permissible with straight-tooth bevels. It may here be mentioned that the fact that the pressure eases off towards the ends of the teeth is the result of cutting the co-operating tooth surfaces of a pair of gears with cutters of the face mill type, the cutting edges of which are of slightly different radii. If theoretical spiral curves were used instead of circular arcs, the practical advantages above referred to would disappear, since the contact pressure would be equal along the whole length of the teeth. Similar tests to those above described are made after the heat treatment processes have been carried out, to detect any possible distortion and also to see that the shafts of pinions have been ground concentrically with the pitch line.

After the initial test above referred to, the gears are passed into the heat treatment department



FIGS. 7 TO 9. QUENCHING MACHINE FOR SPIRAL BEVEL GEARS.

which is housed in a separate building. The actual treatment employed, of course, depends upon the class of steel from which the gears have been cut, but, in general, the gears are packed in boxes with a mixture of charcoal and soda ash and heated in gas-fired furnaces to produce a case of the required thickness. The gears are allowed to cool in the boxes and afterwards reheated and quenched in an oil bath by means of a special machine that will be described later. Five Richmond furnaces, measuring 5 ft. 9 in. by 2 ft. 9 in. by 1 ft. 6 in. high internally, are installed in the department, with a full equipment of Cambridge pyrometers of the thermo-couple type for temperature control. The installation also includes a Brayshaw salt bath furnace, a Richmond oil-tempering bath, a sand-blast plant, scleroscope and Brinell hardness testing machines, as well as three of the quenching machines above referred to.

One of the quenching machines in use is illustrated in Fig. 7 on the present page, while its design and construction can be followed from the sectional drawing reproduced in Fig. 9 annexed. As will be seen, the machine comprises a cylindrical cast-iron tank, 3 ft. 6 in. in diameter, to the upper edge of which is fixed a three-legged casting carrying a vertical pneumatic cylinder. The piston rod of the latter carries at its lower end a die, which is balanced by an annular counterweight fitting loosely round the cylinder. To the bottom of the tank is fixed a long hollow piston and on this fits a movable cylinder which is normally held in the position shown in Fig 9, *i.e.*, with its upper end just above the level of the oil in the tank, by means of a counterweight connected to the cylinder by chains passing over pulleys. The upper end of the cylinder is covered by a plate with radial grooves on its upper face, and on this plate the gear ring to be quenched is placed as shown in Fig. 8; the special tongs used for handling the hot gear rings can be seen in Fig. 7. The plate is also fitted with a loose ring to support the undercut part of the gear ring, and with a set of segmental expanding jaws which are normally a loose fit in the central hole in the gear ring.

When the hot gear ring has been placed in position, air at a pressure of from 80 lb. to 90 lb. per sq. in. pressure is admitted to the pneumatic cylinder, causing the upper die to descend and clamp the gear ring between the die and the upper plate of the movable cylinder. The teeth of the ring fit into a groove turned in the upper die, the inner flange is held by a spring ring, and a spring-mounted cone in the upper die causes the expanding jaws to open and grip the inner edge of the gear ring. When the air pressure is sufficient to raise the counterweight attached to the lower cylinder, the latter is forced downwards plunging the gear ring into the oil and at the same time forcing the oil contained in the cylinder up through holes in the cover plate and on to the ring. The oil escapes horizontally through the radial grooves in the cover plate and also upwards through vertical holes in the upper die, flowing over practically the whole surface of the gear ring, including the spaces between the teeth. In this way the ring is rapidly and effectively quenched, and any distortion from the plane or circular form is prevented. It will be noticed from Fig. 9 that the oil enters the lower cylinder through holes in the side, but these holes are, of course, covered as the cylinder is forced down, the only escape for the oil then being through the holes in the cover plate. It will also be obvious that the oil in the tank is thoroughly stirred by the movement of the counterweight, but it should be mentioned that the oil is cooled by circulation through an external tubular cooler, the heated oil being drawn off from the top through the overflow pipe on the right of Fig. 9 and returning through a pipe passing upwards through the axis of the fixed piston and into the movable cylinder. The coolest oil will thus flow over the gear ring in the last stage of the quenching process. The quenching machine, we should add, as well as the roughing and finishing machines above described, are manufactured by the Gleason Works, Rochester, N.Y., U.S.A., for whom Messrs. Buck and Hickman, Limited, 2, 4 and 6, Whitechapel-road, E.1, are the sole British agents.

In the subsequent grinding process by which

the gears are finished, only the faces, backs and inner edges are ground, in the case of gear rings, and the shafts in the case of pinions; the working faces of the teeth are not touched in any way. The grinding is carried out on Brown and Sharpe and Rivett machines, which call for no particular comment. Some interior views of the Willesden works are given on page 46. Of these, Fig. 10 shows the bay in which the roughing machines are situated at one end of the main building, while Fig. 11 shows two of the five testing machines with some examples of the work carried out on them. One of the bays containing the finishing machines is illustrated in Fig. 12, while Fig. 13 shows some of the lathes used for turning the blanks.

We may mention, in conclusion, that the works produce a large number of finished camshafts for motor-car and aeroplane engines, the plant including four cam-milling machines, Brown and Sharpe grinding machines specially fitted for work on cams, and cam-grinding machines of the firm's own design. The plant also includes a number of Gleason planing machines for straight tooth bevels, Brown and Sharpe and Fellows machines for cutting spur gears, and gear-tooth rounding machines, as well as the usual equipment of millers, drills and other tools for general work.

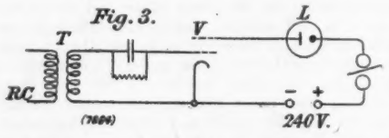
THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

(*Concluded from page* 20.)

CONTINUING our notice of electrical appliances, we pass to the specialities of Messrs. H. Tinsley and Co., of Werndee Hall, South Norwood. The new relay of Mr. H. St.G. Anson is a device making use of a neon lamp in a novel way for rectifying and amplifying signals received so that they may operate some recording or other auxiliary apparatus. When the recording instrument is placed in the plate-circuit of the valve, the adjustment becomes very critical, and when a large balance resistance is added to the same circuit, the amplification is impaired. The neon lamp has the convenient property that its resistance decreases rapidly with the increase of potential across it. Thus a relay requiring a current change of 1 milliampere can be worked in the plate-circuit of the valve containing a neon lamp, with perfect steadiness in spite of fluctuations in filament temperature, signal strength and variations in the high-tension battery.

The change to be made in the grid potential to effect that change of 1 milliampere depends on the signal speeds; it is about 5 volts for the highest commercial speeds which, with a transformer ratio of 5 : 1 in the grid circuit, means 1 volt at the Anson relay terminals. In Fig. 3 V is the valve, T the

Fig. 3.



transformer, R C the receiving coil, L the neon lamp; the relay is seen on the right. The device will pick up any train of waves to be converted into direct currents, *e.g.*, in multiplex telegraphy.

The Phonic Motors, of Dr. Wood, of the Admiralty Research Department, are small motors serving as speed standards and are capable of doing a small amount of work, *e.g.*, driving a kinematograph camera. A solid iron wheel, slotted with 12 teeth, turns within a 12-pole stator, wound for a small electromotive force, being controlled by a tuning fork. Messrs. Tinsley make these motors in two sizes; the larger motor of 5 in. by 5 in. by 4 in., weighs 10 lb.

The variable mutual Inductance Standards of this firm are due to Mr. S. Butterworth. The primary winding is provided with three secondaries of mutual inductances of 1, 3, 6 units; all the conductors are silk-covered stranded wires. Further units are made up by positive and negative combinations to produce which the instrument has two dials, each of divisions 1 to 10. The range is 0·1 millihenry up to 10 millihenry. With the aid of this standard the exact quadrature is determined in the double A.C. potentiometer, between the electromotive force in phase and the c.m.f. in quadrature. Their inductance and capacity bridges are made of the types of Major L. B. Turner (for rapid radio-work), of the Wien type, and further for high-accuracy measurements; the five decade coils of the last bridge contain 10 coils each of 1,000, 100, 10, 1, 0·1 ohms, and the 0·1 ohm section is subdivided by a slide wire to 0·001 ohm, so that the bridge range is enormous.

The new Hamill Flow Meter of Messrs. Elliott Brothers, of the Century Works, Lewisham, is simply mechanical and is primarily intended for indicating the rate of flow, and hence the comsumption of petrol on a motor car. The pointer is actuated by a vane which turns with clearance in an annular chamber against the pull of a spring; the instrument indicates the flow in gallons per hour, the dial divisions being in eighths of a gallon.

The Electrostatic Voltmeter of Messrs. Everett, Edgcumbe and Co., of Hendon, which we illustrated on page 53 of January 13, 1922, is now made for potentials of 300,000 volts. The moving system of the firm's wattmeter, accurate at any power factor, frequency or wave form, weighs only 5 grammes. The portable Ampere-Volt-Wattmeter consists of two boxes, each of which indicates two quantities simultaneously, and of the "Omni-Range Transformer," also contained in a box about a foot square, which has a large hole in the centre. The first three ranges, of 6, 24, 120 amperes, are obtained by means of self-contained primary windings; the further ranges of 240, 400, 600, 1,200, 2,400 amperes are obtained by threading a cable a suitable number of times through the central hole. The still more compact "Dwarf" testing set fits into a case of 5½ in. by 4½ in. by 2¾ in., weighing 1½ lb.

Messrs. Evershed and Vignoles, of Acton, W., drew particular attention to their chart-recording instruments and meters, of the Murday system, for synchronous records, *e.g.*, of current and potential and for measurements of power, speed, &c. The clockwork drives a continuous roll chart, covered with rectangular co-ordinates, and can be moved, by the simple interchange of the gear wheels, at speeds ranging from ½-in. up to 6 in. and 12 in. per hour; the instruments are not restricted to the registration of electric quantities.

The most interesting novelty in measuring instruments, keys, amplifiers, &c., of Messrs. Gambrell Brothers, of Merton Road, Southfields, was their inductance coil holder, so constructed that the coupling between inductances can be varied between a positive maximum, zero and a negative value.

In the position of maximum coupling the three coils 1, 2, 3 of the holder are parallel to one another. If we keep coil 2 fixed and place coil 1 at right angles to it, coil 1 will be at zero coupling; and if we place coil 3 at an angle exceeding 90 deg. with respect to coil 2, coil 3 will be in the negative position. The movements are effected with the aid of long ebonite handles, rubbing contacts maintaining the electric connections with the movable coils.

Messrs. Nalder Brothers and Thompson, of 97a, Dalston-lane, gave prominence to a complete series of instruments developed by Mr. C. L. Lipman, comprising power-factor meters, deflectional frequency meters and a rotary synchroniser; the type C synchroscope with red, green and white signalling device was shown in operation. In this synchroniser the coloured spot of light and the pointer are always in alignment; the position of the light spot consequently indicates the phase angle between the incomer and the bus bars, red and green spots signifying "out of phase" and "nearly in phase" respectively, and the white flash indicating the right moment for closing the switch. The speed of the incomer is adjusted until the coloured spot of light, and with it the pointer, moves slowly round to the vertical mark on the dial, when the paralleling switch may be closed. The novelties of Messrs. Siemens Brothers and Company were an optical pyrometer of the original Holborn and Kurlbaum disappearing-filament type, comprising a compact telescope, with lamps, absorption screen a milliampere meter and a 4-volt battery, and a Lindeck potentiometer, which works without mirror, for the ranges of 2, 5, 15, 30, 60, 75 millivolts.

We can only mention the small, and yet accurate appliances of the Weston Electric Instrument Company, of Ely-place, Holborn, some of which are fitted with pointers of drawn aluminium tubing, less than 0·001 in. in wall-thickness and threaded to carry balance-weights; and the very fine high-frequency instruments of Messrs. H. W. Sullivan, of Winchester House, E.C.; several of these, like the standard wave-meter (range 40 m. to 25,000 m.) built for the Canadian Government, were constructed to the design of Dr. D. W. Dye, of the National Physical Laboratory, and are provided with quartz insulators.

Marconiphones for broadcasting and Subscribers' Sets were exhibited by Marconi's Wireless Telegraph Company, and a fine variety of radio valves and accessories, including silica 4-kw. valves (in protective sheaths) were shown by the Mullard Valve Company, of 45 Nightingale-lane, London. The insulation of the Condensers of the Dubilier Condenser Company, of Goldhawk-road, consists of thin sheets of mica which are cemented together, compressed and then turned on the lathe. Their "Ducon" attachment is inserted into a lamp socket when the light circuit is to be utilised as aerial. The ducon is a small box containing two condensers, each in contact with one socket terminal, and the receiving set may be connected to either ducon terminal; since the characteristics of the two wires of the supply circuit will generally be different, it is said, the two condensers of the ducon have been made different, and either half should be tried.

The Edison-Swan Company had almost limited itself to a brilliant display of their pointolite lamps (up to 10,000 candle), of neon lamps and of lamps which glow all over without showing the filament. Into the top of one of the large pointolite lamp bulbs, a glass bell had been sealed so as to form a kind of hood for the electrodes; the idea, we understand, is that the tungsten vapour rises in the nitrogen atmosphere (at 5 in. pressure) into the bell, is cooled there and streaming back surrounds the electrodes and keeps the further evaporation of tungsten down. The novelty of the Zenith Manufacturing Company, of Villiers-road, Willesden, which showed resistance and choking coils, &c., was the Acdic Electrolytic Rectifier for charging accumulators from alternating mains. The cell is placed in a cooling tank and contains two aluminium sheets acting as one electrode, the cell wall being the other, in an electrolyte (alkali borate or phosphate, possibly) which can be replenished, it is said, with tap water. The connections are made through a double-wound transformer which protects the operator and acts as resistance. The "formite-bakelite" insulating products of the Damard Lacquer Company, Birmingham, made in fine colours, as solid resins, enamels, moulded insulators and lacquers, are said to bear 280 deg. F. without remelting, though not without discolouring; steels coated with acid-resisting lacquers were also shown.

The new type of steam-flow or boiler load indicator of Messrs. George Kent, 199 to 201, High Holborn, will require special description. The Wickman Calliper Gauges and the Ball Hardness Tester of the other engineering firm represented, Messrs. Alfred Herbert, of Coventry, have been illustrated in our columns.

The Automatic Winding Machine of the Igranic Electric Company, of Bedford, and 147, Queen Victoria-street, E.C., is a modification of the Leesona machines which we illustrated on page 274 of our issue of August 29, 1919. The new machine is arranged for winding two coils simultaneously and for automatically inserting paper tape, ranging in thickness from 1 mil up to 6 mils, between the wire layers; the old machines could not deal with paper. The machine was shown winding transformer coils for radio-apparatus, and honeycomb and other inductance coils were exhibited in great variety. The honeycomb coils are mounted either on the orthodox plug-in method or on the new Gimbal method, which admits rotating the coil and of spacing the coils far apart. The firm has taken up the

manufacture of the electrically-controlled Hopkinson valve, which does not connect the motor to the valve before it has attained full speed; the position of the valve is indicated with the aid of coloured lamps.

Insulated Wires, fine silk, enamel and asbestos-covered insulating materials and metal work were further shown by the Concordia Electric Wire Company, 155, Victoria-street, S.W.1, and by the Godwin Manufacturing Company, of 238, Belsize-road, N.W.6; the latter now supply No. 47 and No. 48 S.W.G. copper wires, of 0·002 and 0·001 mm. in diameter.

We lately referred to Liquid Air, Limited, of 111, Salisbury-road, when commenting on the discussion by the Faraday Society of the "Generation of Cold" (ENGINEERING, Nov. 3 last, page 564). Thermocouples (iron-construction, up to 900 deg. C., Pyrkon alloy up to 1,200 deg., platinum-rhodium up to 1,600 deg.) were among their exhibits.

The Pyrometers of the Foster Instrument Company, their Resilia voltmeters, which were explained by a fine model of three times actual size, and their furnace temperature control have been described on previous occasions (ENGINEERING, March 18, 1921, page 318, and January 22, 1922, page 53). Some new alarm devices and lamp signals, marking temperature rise above and fall below fixed limits, were also shown.

The many beautiful exhibits of Messrs. Adam Hilger were well arranged for instructive demonstrations. Their celluloid mirrors are quite a novelty. Films, several inches square, of celluloid are, by means of a special process obtained in a thickness of only a few wave-lengths of light, and are mounted in frames of sheet aluminium; these mirrors are relatively strong, and they offer the advantage that they do not give rise to reflection from back and front, as glass plates would do, while they weaken the light very little and do not affect the definition of the returning beam. The magnified image of a polished steel edge, examined by the aid of this mirror with a microscope by vertical illumination, showed anything but a smooth surface. The new neon lamp which was shown mounted for spectrometer work with a Lummer plane-parallel plate and a new anamorphic eyepiece, is a quartz tube, all filled with neon, enclosing a bell-shaped chamber also of quartz. Before the open front of the bell is placed a vertical plate of aluminium provided with the vertical slit to be brought up to the spectrometer. This aluminium plate is the one electrode for the electric discharge through the neon; the other electrode is an aluminium cylinder (of horizontal axis) fitting into the chamber. To prevent the direct discharge between the two electrodes a plate of mica is interposed between the mouth of the bell and the aluminium plate; there is a hole in this mica plate, through which the neon can escape into the outer tube, which, as we mentioned, is itself filled with neon. The neon glow is steady and intense; the device is an improved Osglim lamp, fitting into ordinary sockets. Certain neon lines have been adopted as wave-lengths standards by the International Astronomical Union.

The Schumann plates of the firm, for wave-lengths 220 to 90 A.U., have been used by Sir J. J. Thomson for his positive-ray analysis; sealed up in canisters they will last over two years. Diffraction gratings, ruled by the National Physical Laboratory on speculum metal, were also displayed. There were further ilmenite arcs, rough crystals of ilmenite (titanium-iron) mounted in copper rods, which give bright lines of the two metals convenient for spectroscopic work. The vacuum thermopiles of high sensitivity, almost free from creep, also exhibited, are made of Hutchins' alloys, bismuth-tin and bismuth-antimony, which Messrs. Hilger find far superior to the first-used bismuth-silver and bismuth-iron couples. Their Reststrahlen apparatus, in which infra-red radiations are sifted and purified by repeated reflections, is of the type which Rubens and Hohlnagel described in 1910. Most of the other apparatus have been mentioned by us on previous occasions; the new interferometer for laboratory purposes is a small-scale apparatus for determining the contours of lenses and prisms of the type which we illustrated in our issue of December 30, 1920, on page 857.

The one novelty of the firm which we illustrate in Figs. 4 to 6 is the Hilger Interference Accessory for Testing Microscope Stands and Fine Adjustments. Even the most rigid modern microscope stands are subject to a certain amount of vibration which will vary the distance between object and objective; the device measures this variation. It consists essentially of a conical box A (see Figs. 4 to 6),

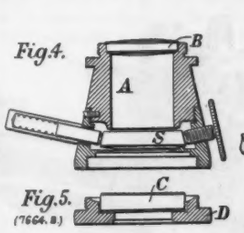
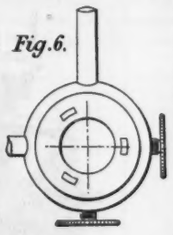


Fig.5. (7664. 8.)



which is closed by a lens B on the top and by a silvered glass plate C below, and of the cell D. In use, the cell D carrying the glass plate C is unscrewed and placed on the microscope stage, resting for this purpose on a microscope slide; the box A itself is screwed, by the thread T, in the place of the removed microscope objective.

Before attempting any adjustment, the box A is gently lowered by the focussing mechanism until it touches the cell D and is then raised by 1 mm. or 2 mm. Light from an Osglim lamp (or mercury vapour lamp) is reflected up by the plane mirror, the microscope condenser having been removed. Blurred images of the source of light will be seen, but by adjusting the screws S these multiple images can be made to overlap. The concave mirror of the substage is now put in position; interference rings are then seen in constant agitation, and the agitation is a measure of the vibrations. When one ring increases in diameter so as to replace the next, the distance through which the microscope body has moved relative to the stage will be $\frac{1}{1000}$ mm.

The chromoscope shown by the Chromoscope Company, 4, Broad-street-place, is a novelty of considerable importance to those interested in the combination of colours for artistic designs of textile fabrics, wall papers, ceramic products, and in decorative arts generally. At present the designer wishing to see how his design would look in a different colour combination has to make separate paintings for each colour shown. The Chromoscope Company proceeds as follows. Supposing the pattern is to be in five colours. A rendering in black of each of the five portions of the pattern is made; a rectangle is ruled on each of the five portions, photographic negatives are taken from the drawings; the five negatives are placed on five slides of the instrument and colour filters are applied. The box in which this is effected is a case about 5 ft. high, open in front, and divided by vertical partitions into five compartments. In each compartment there is a lamp (gas-filled Osram daylight lamps) at the top; on a shelf underneath is placed the Wratten colour filter or screen and, immediately underneath, the negative; further below is a transparent mirror at 45 deg.; at the bottom of the box lies horizontally another mirror. The light falls from the lamp through the screen, the negative and the two mirrors, the passage through the mirrors being as in a Michelson interferometer, *i.e.*, down, up again, and sideways by transmission and reflection. In the next compartment the same negative and another colour screen are used; the bottom mirror in this case lies a little higher, the bottom being arranged in step fashion. The five systems of rays all issue in the same direction laterally and are examined through a telescope or binocular mounted in the side of the box; the effect of exchanging the colour screens can thus at once be seen, the manipulations being made in one or in several compartments. The model exhibited was capable of showing up to ten colours. The mirrors, 4 in. square, are the already-mentioned celluloid mirrors of Messrs. Hilger.

The monochromatic illuminator and other specialities exhibited by Messrs. Bellingham and Stanley, 71, Hornsey-rise, were illustrated on page 659 of our issue of May 26 last.

In the double-reading micrometer theodolite of Messrs. C. F. Casella and Co., of 49-50, Parliament-street, the diametrical points of the dividing are brought together in one field. When the telescope is set, all four readings of the circle can be taken on one micrometer without walking round the instrument, the number of parts is reduced, and there is no need for setting four micrometer heads. The vertical circle is carried in tapered sockets (in the uprights), of great wearing surface, but not revolving on them. The lighting does not require an extra attachment, the battery wire is governed by a ply to the tripod, and the current is carried up through the axis of the circle so as not to interfere with the settings in azimuth and altitude. These and other improvements fit the theodolite for geodetic work of high order. The Tudsbery indicator made by the firm, described on page 631 of our issue of November 17, page 631, has since been used on the Queensferry Bridge over the Dee, and Dr. Owen's air filter and new jet apparatus were last mentioned in our 1922 British Association report (October 13, page 473).

The manifold exhibits of Messrs. Cooke, Troughton and Simms, of 3 and 5, Broadway, Westminster—the firms of T. Cooke and Sons, Ltd., and Troughton and Simms recently amalgamated—exemplified the great recent advance in the construction of theodolites and cognate instruments for surveyors and miners by the instruments used in the construction of the Forth Bridge and on the Antarctic expeditions of recent years. Their new direct-reading tacheometer, due to Dr. H. H. Jeffcott, has rendered excellent service in India for the determination of heights and distances. It resembles an ordinary tacheometer without vertical circle, but it is provided with movable stadia lines, the distances between which is automatically controlled by the tilt of the telescope so that the intercept on the graduated shaft multiplied by 100 (by 10 for the height) gives the horizontal distance without the use of slide rules or tables.

The special balloon theodolite, with which its designer, Mr. A. D. Simms, gained some war experience in Palestine, and which was used also on the Shackleton-Rowett expedition, is an instrument designed for the study of the upper air currents, and tells an aeronaut whether he might reckon on a favourable wind for his return journey. The instrument is constructed on the lines of the broken-axis type of theodolite, observations being made from one end of the transit axis so that, whatever the position of the altitude circle, the location of the eye-piece is the same. The telescope has a focal length of 10 in., and the object glass a diameter of 1½ in. The direction of the telescope axis is changed by means of a pentagonal prism, arranged to read from a single index. Two operators are required; the one effects the telescopic directions, the other records the altitude and azimuth readings at known intervals. Each circle is operated by two lead screws, one revolution of which corresponds to 2 deg.; these screws can instantly be put out of action and the circle be released by a cam.

The miners' dip needle of Professor Henry Louis can be used as an ordinary compass when horizontal or, when suspended from its encircling ring, as a dip needle for tracing magnetic ores; the needle is of special form to control the sensibility and is balanced by adjustable weights to read against the zero of the circle when held in meridian. The miner's dial has been improved in consultation with leading surveyors; it rests on a tripod of duralumin, the plumb-bob being suspended from a metal sphere, and plain sights and telescopes, almost of theodolite finish, may be interchanged without disturbing the line of sight.

The surveyor's camera of Messrs. Ottway, Ealing (represented by Messrs. B. J. Hall and Co., Great Peter-street), is a photographic camera on a tripod stand so arranged that the position of the divided celluloid ring of the floating compass appears on the plate. The surveying level of Messrs. E. R. Watts and Sons, of 123, Camberwell-road, embodies a peculiar novelty, the constant spirit level of Mr. S. Weston which, it was demonstrated, shows no alteration in the length of the air bubble with a temperature variation

from — 4 deg. up to + 280 deg. F. The constancy is ascribed to the peculiar curvature of the level glass, which is flat with curved surfaces (not circular), favouring an expansion and contraction cross ways rather than longitudinally. This constancy would facilitate theodolite work in climates of extreme temperature changes.

Lanterns and episcopes were exhibited by Messrs. Newton, 72, Wigmore-street, and by Messrs. Davidson, 29, Great Portland-street (Davon micro-projector). The most striking exhibit of Messrs. Ross, of Clapham Common, was a new compact kinematograph projector, weighing 5 cwt.

The great variety of microscopes was instructive as such and also because Messrs. R. and J. Beck and other firms had especially arranged their exhibits so as to demonstrate the advantages of different types of illuminators and other features. For object glasses of high power, Messrs. Beck recommend their dark ground immersion illumination now fitted with an illuminator of 1·2 N.A.; for opaque objects their aplanatic ring illuminator, a silvered glass ring, so arranged that the right is thrown upward. Messrs. Watson and Sons, of 313, High Holborn, attach a horizontal lamp tube to the body of the microscope for vertical illumination by the aid of a mirror. Messrs. Ogilvy and Co., of 18, Bloomsbury-square, W.C., demonstrated that vertical illumination may be very misleading; a dull-black mirror appeared white with blank patches, but uniformly dotted when illuminated by the ring-filament of Silverman, which embodies the objective like a collar. Messrs. C. Baker, of 244, High Holborn, exhibited concentric dark ground illuminators, fluorite lenses and other apparatus. Messrs. J. H. Dallmeyer, of Willesden, demonstrated the construction of a photographic lens by the aid of a kinematograph and exhibited their pentac anastigmat lens, now made of the very large aperture of f/2·9.

The National Physical Laboratory had brought one of their constant temperature baths, actually to demonstrate the testing of clinical thermometers. Of Messrs. Negretti and Zambra's numerous exhibits we can only mention that the new barograph is fitted with Mr. Ibbott's helical flat spring replacing magnifying levers. Messrs. Rheinberg and Co., of 57-60, Holborn Viaduct, exhibited a fine collection of their manifold graticules. Their workshop test of the bores of capillary tubes is made by pushing the capillary horizontally up to a stop and examining the front by the aid of an inclined microscope over the background of a rectangular graticule, the sides of the rectangles corresponding to the maximum and minimum diameters permissible. We regret not to be able to notice several exhibits.

THE SMALL POWER ENGINEERING AND SCIENTIFIC EXHIBITION.

THE manual constructive abilities of large numbers of people find little exercise in the course of their everyday life, and many take to the fascinating hobby of model making to satisfy this side of their nature. All are impressed with the delicate workmanship necessary to the production of a much-reduced copy of any piece of engineering plant and marvel at the patience shown by the enthusiasts who may spend years of their spare time in the production of their best examples. There is also, of course, a professional side to this type of work in the production of models for large engineering and shipbuilding companies for use in demonstrating the operation of newly-introduced devices and, in a way that is much more striking than by means of drawings or photographs, the examples of work they have constructed. Both classes of work were shown in the sixth exhibition organised by *The Model Engineer*, which was held in the Royal Horticultural Hall, Westminster, from Friday, January 5, until to-day.

The difficulties which must be encountered by the amateur worker, who has but a very limited selection of tools, mostly of the hand type, at his disposal, in the course of constructing his models must be very great, but their surmounting gives scope to his imagination, develops his sense of confidence in his abilities and must widen the sphere in which he can do much with the use of few aids in the way of equipment. Few advantages the model worker has to start with, except the inborn desire to create something that is workable, but his finished work must satisfy the demands of a most exacting nature. That any man should devote the spare time of eighteen years in building a model of an engineering workshop completely equipped with 14 machine tools, is evidence of the nature of the men who take up this hobby. This model was, perhaps, the most remarkable in the whole exhibition. The plant consists of five lathes of different types, four drilling machines, two planers, and one shaping, one slotting and one milling machine. The model represents a steel-constructed works with eight pairs of uprights of H-section and 15 trusses, while the roof is "glazed" with 600 pieces of mica. The floor is covered with wood blocks and everything is constructed to a scale of 1 in. to 1 ft. Mr. E. J. Windsor, who constructed the model, favours realism and was not content with the works, the machine tools, the engine, shafting, benches, vices, and other small equipment, until he added a barrow filled with turnings and a small scrap heap in one corner of the shop. It is difficult to single out other examples among the many for special comment, because in a show where so much is excellent little can be said in a short article without creating invidious distinctions. Many loan models were on show, and included a locomotive built in 1848 by Thomas Thornycroft, the father of the founder of the firm of Messrs. John I. Thornycroft and Co., Limited. Another model from the same hands, and of considerable historic interest, was a boat which shows what is supposed to be the first use of the closed stokehold system of forced draught. Professional model making was well illustrated on the stand of Messrs. Twining Models, Limited, where examples of a motor lorry, a Yarrow marine-type water tube boiler and several railway engines, all constructed for industrial concerns, afforded typical examples.

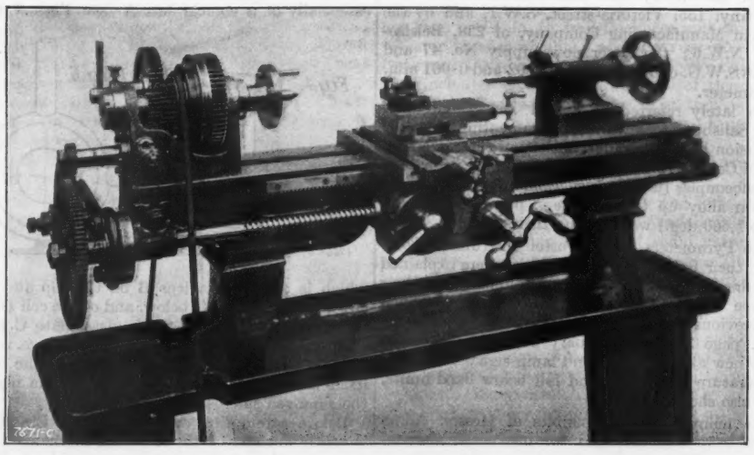


FIG. 1. 3-IN. CENTRE LATHE; MESSRS. ARTHUR FIRTH, LIMITED, CLECKHEATON, YORKS.

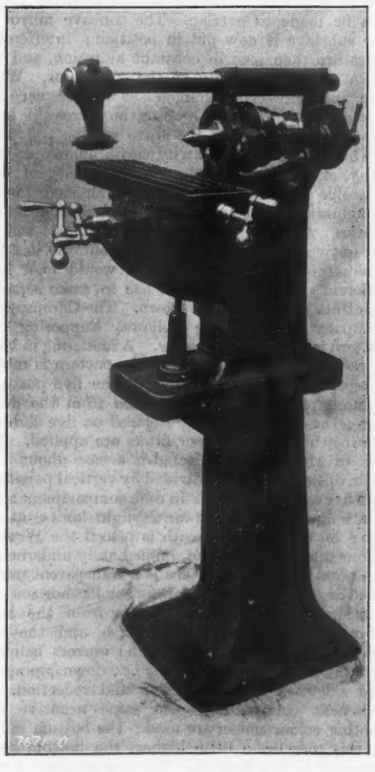


FIG. 2. BACK-GEARED BENCH MILLING MACHINE; MESSRS. ARTHUR FIRTH, LIMITED, CLECKHEATON, YORKS.

The popularity of "listening-in" was indicated by the great number of stands that showed wireless telephone equipment. Not only were complete outfits of the crystal and the valve type exhibited but also the component parts, that those so inclined may have the advantage of constructing their own installations, as might be expected would be the course adopted by model engineers.

The small tools shown in the exhibition reflected the combination of good workmanship and design for cheap production which is the characteristic in this field. With a scope so great as there is in model engineering, the production of cheap standard tools is a necessity and the show provided examples of the various types commonly in use some of which we illustrate on this and the opposite pages.

The "Atlas" 3-in. centre, geared screw-cutting lathe, made by Messrs. Arthur Firth, Limited, of Cleckheaton (see Fig. 1), is in general design much like the heavier modern machines of large size. It is a model of the large general lathes. The bed is of box-section, ribbed internally and is planed to the usual 90 deg. V-edges back and front. A self-contained box-pattern of headstock with back gear is fitted, with the reverse gear inside the headstock. The spring clutch and plunger facilitates speedy operation of the speed cone and spindle gear. A hollow spindle, bored out $\frac{3}{8}$ in., is run in gun-metal bearings of the conical type at the front and parallel type at the back. Ball thrust washers take the thrust at the back bearing. The saddle is of the boring carriage type and is fitted with a quick hand traverse by means of the steel rack and the double gear pinions on the apron. The swivel slide on the slide rest is graduated and indexed for angle

and taper work. A micrometer collar fitted in gun-metal nuts is provided for the cross-slide screw. The lead screw has a square thread and double clamp nuts are used. A small back-geared milling machine, manufactured by the same firm, is shown in Fig. 2, and is designed on similar lines to the larger machines of the latest type. The table is 4 in. wide and 18 in. long, with three machine-cut T-slots the entire length, and has a longitudinal and cross traverse of 8 in. and 4 in. respectively. A rise and fall motion for the table has a 6-in. travel.

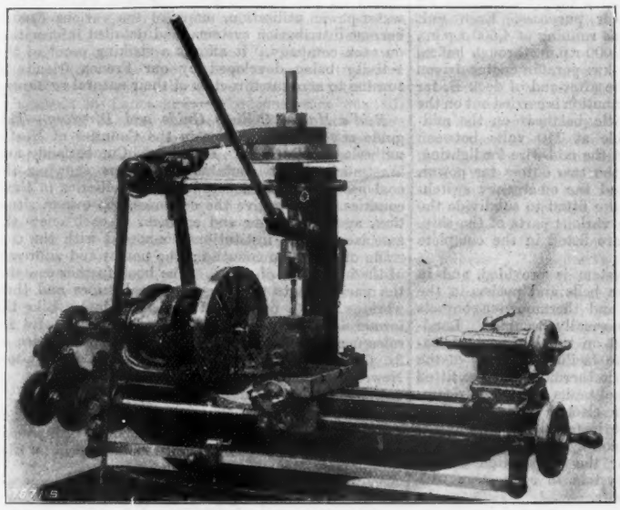


FIG. 3. 3½-IN. CENTRE LATHE WITH VERTICAL DRILL; MESSRS. DRUMMOND BROTHERS, LIMITED, GUILDFORD, SURREY.

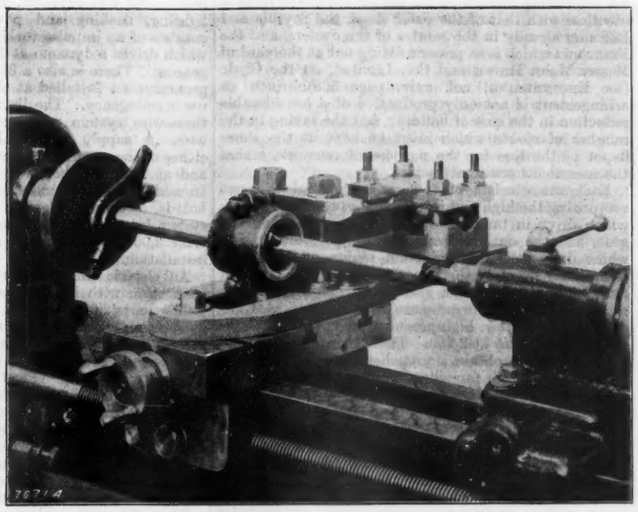


FIG. 4. CONNECTING-ROD BORING ATTACHMENT FOR LATHE; MESSRS. DRUMMOND BROTHERS, LIMITED, GUILDFORD, SURREY.

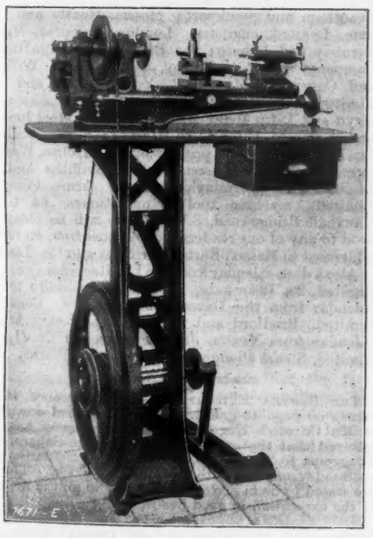


FIG. 5. TREADLE LATHE; JACKSON RIGBY ENGINEERING COMPANY, LIMITED, SHALFORD, SURREY.

Messrs. Drummond Brothers, Limited, of Guildford, exhibited examples of their standard lathes, drilling machines and shapers, and the "Willing Worker" 3-b.h.p. paraffin engine which we recently described in ENGINEERING (see vol. cxiv, page 707). The "Little Goliath" lathe is only of 2-in. centres, and takes work up to 5 in. length. It was shown on the stand used in three different ways—first, as a treadle-driven lathe; second, as a small vertical milling machine; and third, as a vertical drill. Special conversion parts are manufactured for use in connection with the lathe for its other purposes. The lathes of 3½-in. and 4-in. centres are the main articles of manufacture of this firm. The illustration, Fig. 3, shows the 3½-in. model combined with a small drill. The bed of the lathe is of box-section and of the cantilever type. The headstock is clamped against the flat vertical face of the front bed shear. The cone pulley has flat steps. Ball thrusts are fitted to the hollow spindle which runs in phosphor bronze bearings that are adjustable in their coned seatings in the casting. The lead screw is fitted with a rear end bearing with a bronze bush, and is provided with a clutch at the headstock end. An arrangement is available for both hand and automatic throw-out, which can be set to operate at any position of the saddle along the bed and prevents over-running. A spring plug retainer is fitted to each of the screw-cutting gear-changing studs. The illustration shows the attachment of a drill to the lathe so that the common turning operations and vertical drilling may be performed on the same piece. The drill is belt-driven from the pulleys rotated from the treadle and the drive is taken through jockey pulleys to the drill spindle. Fig. 4 shows a new accessory provided for use with Drummond lathes; this is a clamp for use when boring the ends of connecting rods. The gudgeon pin of the small end is held in a Vee block at the back. The clamping plate at the front has a curved underside and serves to prevent the springing of the connecting rod when the boring operation is in progress. A screw jack below the big-end is used to obtain the correct height of centre for the work. Similar fittings are being produced for this work on the larger lathes made by the firm.

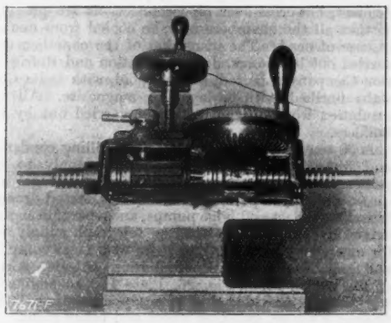


FIG. 6. LATHE APRON; MESSRS. HENRY MILNES, BRADFORD.

A small treadle lathe made by the Jackson Rigby Engineering Company, Limited, of Shalford, Surrey, is shown in Fig. 5. It is a 3-in. centre screw cutting type. The bed and headstock is a single casting, the bed part being of box-section. The steel mandrel is hollow and is provided with parallel journals and Hoyt hardened copper split bearings. A curved offset type of tailstock is securely clamped and aligned by one movement of a lever. The top slide rest is suitable for surfacing work of 6 in. diameter. Lever grips secure the top slide at any angle. There are micrometer feeds to the head screw and the top slide. The belt is clear of any part of the pedestal structure and the flywheel is beside the belt pulley. The Britannia Lathe and Oil Engine Company, Limited, of Colchester, exhibited their lathes, which were described in ENGINEERING, vol. cxiv, page 12.

The apron fitted to the lathes manufactured by Messrs. Henry Milnes, of Bradford, is of unusual design and is shown in Fig. 6. The leading screw nut is in one unit with a bevel pinion, and the end thrust is taken by a ball thrust washer at each end of the nut. This bevel pinion meshes with a bevel wheel which is solid with the hand wheel on the front of the apron. The leading screw nut is held stationary for sliding and screw-cutting work by means of a small plunger knob, which on being turned round engages with any of the six projections round the nut. For screw cutting one of the projections is made longer than the others and a quarter turn of the plunger knob engages this projection only. When the plunger is out of engagement, the nut revolves with the leading screw and provides an automatic lock to the saddle.

THE LINERS CONTE ROSSO AND CONTE VERDE.—A very handsome and profusely illustrated book has been issued by the Lloyd Sabaudo, on the occasion of the entering in service of their ship Conte Rosso; it refers also to the sister ship Conte Verde, which latter is nearing completion. It gives historical notes on the House of Savoy, with particular reference to the two Counts in question, together with an illustrated description of the Conte Rosso, this being taken from ENGINEERING of February 17 and 24 last. Various features of the ship are illustrated and described. It also contains notes on and views of Italian towns and country places, and other items of interest including notes on Italian musicians and a number of examples of Italian music. The book is admirably finished and reflects great credit upon the printers, Messrs. Barabino and Graeve, Genoa.

TRANSFORMER SAFETY DEVICE.—A novel method of minimising fire risk with large oil-cooled transformers is being introduced by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Pa., U.S.A., and has found its first application in connection with a 25,000-k.v.a. bank of transformers which the Westinghouse Company has supplied to the Middle West Power Company to the order of Messrs. Sargent and Lundy, consulting engineers, of Chicago. The method consists in filling the transformer case, above the oil level, with nitrogen, which is, of course, incapable of forming an explosive mixture with vapours rising from the oil. The nitrogen is supplied by an automatic generator fixed to the transformer case. It is also suggested that the layer of nitrogen above the oil acts as a cushion or buffer helping to absorb shocks due to sudden pressures generated by arcs under the oil level, in case of breakdown.

THE CUNARD LINER "SAMARIA."

(*Concluded from page* 9.)

THE propelling machinery, consisting of two sets of Brown-Curtis compound steam turbines, with the auxiliary plant, steam-pipe connections and boilers is shown in Figs. 25 to 29, Plate IV. A sectional view through the ship (Fig. 30) gives another view of the boilers. The plant was constructed in the Birkenhead works of the builders, Messrs. Cammell Laird and Co., Limited, but the shafting and other heavy forgings were made at the firm's establishment at Sheffield. An interesting feature of the design is that the plant is identical with that of the sister ships, the Scythia and Laconia, already in the service of the owners, and the Franconia which is at present fitting out at the yard of Messrs. John Brown and Co., Limited, on the Clyde (see ENGINEERING, vol. cxiv, page 528). Such an arrangement is not only productive of a considerable reduction in the cost of building, but the saving in the number of spares which must be kept at the shore depot of the line for the purpose of renewals, makes the scheme otherwise attractive.

Each set consists of two units, the inboard one comprising the high and intermediate pressure turbines which drive in tandem to one of the pinions on the gear, and the outboard one, the low-pressure turbine which drives the first-reduction pinion on the other side. This drive is then carried through the second reduction pinions to the gear wheel mounted on the main shaft. The low-pressure turbine runs at 1,770 r.p.m., while the high-pressure and intermediate-pressure unit runs at 2,750. These speeds are reduced by the gears to obtain a propeller speed of 90 r.p.m. The thrust of each propeller is taken by blocks of the Michell type. Astern turbines are incorporated within the exhaust casings of the intermediate and the low-pressure turbines. At any time when it is required arrangements are available for driving either the high- and intermediate- pressure turbines set or the low-pressure unit alone.

The turbines are supplied with steam from three double-ended and three single-ended multitubular return-tube boilers of 17 ft. 6 in. diameter. The double-ended boilers are 22 ft. 6 in. long and the single-ended ones are 11 ft. 6 in. long. There are four Morrison furnaces in the single boilers and a similar construction is used for each end of the double boilers, and each furnace tube is connected to a separate combustion chamber. Among the fittings to these boilers are Diamond flue blowers, Brundrit's temperature balances and the Cumberland electrolytic equipment for the prevention of corrosion. The steam pressure is 220 lb. and the steam is superheated to 600 deg. F., about 200 deg. F. above the saturation temperature.

The superheaters are of the marine or locomotive type, the steam pipes of which are situated within the smoke tubes of the boilers. Mixing valves are used to regulate the amount of superheat to the requirements.

Oil fuel is burned under forced draught on the Wallsend-Howden system with four separate plants, as can be seen in the boiler room part of the drawing in Fig. 26, Plate IV. The combination of two of these sets—one large and one small—is of sufficient capacity to deal with the whole duty at full power. An oil-fuel transfer pump and an oil-fuel bilge-well pump are provided, and each may be put on either duty. There are two oil-settling tanks, one on each side of the passage between the turbine and the boiler rooms. Each of these two tanks holds sufficient oil for 12 hours' continuous running at full power. A double bottom extends almost the whole length from stem to stern and is carried well up the sides. It is arranged to carry water ballast, feed water for the boilers and oil fuel. Five pairs of tanks in the double bottom are used for oil-fuel storage and there are also two large deep storage tanks between the engine and boiler rooms. Steam-heating coils are fitted to these tanks, and Pneumercator-gauge equipment, constructed by Messrs. Kelvin, Bottomley and Baird, Limited, of Glasgow, is fitted to them and also to the settling tanks beside them. Oil-filling connections are provided on both sides of the vessel, and each can pass 250 tons of fuel oil per hour.

The main condensers are placed directly below the low-pressure turbines. The condensate extracted from them is dealt with on Weir's closed feed system, in which the boilers are supplied with de-aerated feed water at a high temperature. The equipment for the system consists, in addition to the condensers, of turbo-extractor pumps, air ejectors, turbo-feed pumps, feed heaters and filters.

An efficient system of forced lubrication is installed. Three direct-acting pumps are used to draw oil from the oil drain tank below the gear cases and deliver it through strainers and coolers to the gravitation tanks in the engine-room hatch. There are two separate tanks, the first supplies the turbine and gearing bearings and the thrust blocks, while the other provides oil for the gearing sprayers which direct the oil between the teeth of the wheels of the gearing. These gravitation tanks may be by-passed and the oil delivered direct from the pumps through the filters and oil coolers to the bearings and sprayers. The lubricating oil is purified by the use of a De Laval plant. Tanks are fitted in the engine-room hatch to store the lubricating oil. Single-acting bilge and sanitary pumps are driven from the main gear wheel shaft. The propellers are of the built-up type with four manganese bronze blades.

In the engine room between the two main shafts (see Fig. 26, Plate IV) are situated two turbo-generator sets of 375 kw. capacity, which supply electricity for lighting, cooking and power purposes. Each unit consists of an impulse turbine running at 4,500 r.p.m., which drives a dynamo at 1,000 r.p.m. through helical gearing. There is also a 36-kw. paraffin engine-driven generator set installed at the after-end of deck B. for use in emergency. The distribution is carried out on the three-wire system with static balances on the mid-wire. A supply is available at 110 volts between either of the outer wires and the mid-wire for lighting, and at 220 volts between the two outers for power. In addition to the main and the emergency switchboards, distribution boards are fitted to subdivide the system into sections for the various parts of the ship. Over 3,000 electric lamps are fitted in the complete installation.

An electric fire alarm system is provided, and in connection with it there are bells and pushes in the public parts of the vessel, and thermometer-contacts in such places as are not normally occupied. Loud-speaking telephones, worked on the intercommunication system, are installed to facilitate control of the working of the ship. Electric thermometers are fitted in connection with the oil-fuel tanks and the refrigeration chambers. The other electric fittings include Pulsinetic clocks, which are installed throughout the ship, electrolytic anti-corrosion system for the boilers, a sea-water electroliser for the preparation of disinfectants, and an alarm system in connection with the watertight bulkhead doors.

The refrigerating plant was constructed by Messrs. J. and E. Hall, Limited, of Dartford, and consists of two large carbon-dioxide evaporators, four condensers and motor-driven pumps for brine and cooling water. The two sets of refrigerating plant are quite independent, but cross-over pipe connections are provided so that all the chambers may be cooled from one set in case of need. The insulation of the chambers was carried out by Messrs. J. D. Insulation and Refrigeration Company, Limited, of Liverpool, with Delta Cork slabs finished with a layer of magnesite. All the insulation work on the holds was carried out by the builders.

A 50-ton evaporator plant with distilling condenser and filter, calorifiers for hot water supply to the passenger accommodation, alternative centrifugal and direct-acting feed pumps for the boilers, forced-draught fans, fire, ballast and bilge pumps, and a paraffin engine-driven dynamo for the wireless telegraph supply and for emergency pumping, are parts of a most complete and extensive system of auxiliaries. At one corner of the engine room, Fig. 26, Plate IV, an engineer's workshop is provided and is equipped with a lathe, drilling machine, grinding wheel and other plant.

YEAR BOOKS AND ANNUALS.

Willing's Press Guide, 1923.—James Willing, Limited, 30, King-street, Covent Garden, W.C. 2 (price 2*s.* 6*d.*). The present edition, the fiftieth annual edition of this press guide, gives the title of every journal published in the United Kingdom, the year of its first publication, the day of the week on which it appears, price and address. It also contains a list of the journals arranged according to the specialities with which they deal, other lists arranged under countries and towns, and lists of Colonial and foreign journals, together with information of interest to all concerned in press work.

Clubs, 1923.—This is a handy book, edited by Mr. E. C. Austen-Leigh, M.A., and published at the price of 7*s.* 6*d.* net, by Messrs. Spottiswoode, Ballantyne and Co., Limited, New-street-square, E.C. 4, giving the names of London, provincial, colonial and foreign clubs, their address, date when established, membership, fees, name of secretary and class of club.

Annuaire, 1923, *Bureau des Longitudes.*—The Bureau des Longitudes, Paris, was instituted in June, 1795, and is formed of three members of the French Science Academy, five astronomers, three members of the Navy Department, one member of the War Office, and one geographer, amongst others. They compile the annual bearing the above title, which is published by Messrs. Gauthier-Villars and Co., 55, Quai des Grands-Augustins, Paris; the price of the present edition being 6·50 francs net. It contains a large amount of astronomical, meteorological and other information, tables giving population of large cities; altitudes; ocean depths; length of rivers; area, population and density of population of all the countries in the world; climatic figures, &c., and forms a valuable reference guide.

Annuaire de la Houille Blanche Française, 1922–23.—Edited by Mr. A. Pawlowski; offices of the *Revue Générale de l'Electricité*, 12, Place de Laborde, Paris 8. This annual constitutes a complete guide to the work carried out and planned throughout France for the generation of current for light and for power in every application, by utilising the waterfalls and rivers throughout the country. It opens with general statements on the subject, gives the laws which govern water-power utilisation, maps of the various French current distribution systems, and detailed information on each company. It affords a striking proof of the activity being developed by our French friends in turning to account this class of their natural resources.

Reid's Handy Colliery Guide and Directory.—This guide covers the collieries in the Counties of Northumberland, Durham, Yorkshire, Cumberland and Westmorland. It contains two maps showing the coal basins and the location of the collieries in these counties. Tables give the collieries, the owner, situation, agent, manager and engineer of each one; the associations and institutions connected with the coal trade of the same counties; the names and addresses of the inspectors of mines. The book further contains the various Acts which govern coal mines and their working, also a number of statistical data. Like the former issues, this guide book will prove useful for reference purposes. It is published at the price of 3*s.* 6*d.* by Messrs. Andrew Reid and Co., Limited, Newcastle-upon-Tyne.

Diaries.—A handy vest-pocket diary has reached us from the Clay Cross Company, Clay Cross, near Chesterfield, illustrating their metallurgical works, by-product coke ovens and collieries.

Almanacks and Calendars.—We have received monthly tear-off calendars from Messrs. R. and H. Green and Silley Weir, Limited, ship and engine repairers, Blackwall, Thames Iron Works, Falmouth, &c.; Messrs. Ruston and Hornsby, Limited, Lincoln, Grantham and Stockport; Messrs. Heatly and Gresham, Limited, engineers, London, Calcutta, Madras, Bombay and Lahore; the British Thomson-Houston Company, Limited, Rugby, Birmingham, Willesden and Coventry; Messrs. R. Y. Pickering and Co., Limited, rolling-stock manufacturers, Wishaw; the Kryn and Lahy Metal Works, Limited, steel founders and engineers, Letchworth (Herts.); Messrs Williams, Lea and Co., Limited, printers, Clifton House, Worship-street, E.C. 2; Messrs. Burton, Griffiths and Co., Limited (The Birmingham Small Arms Company, Limited), machine tool manufacturers, 64 to 70, Vauxhall Bridge-road, S.W. 1, who will be pleased to send to any of our readers a copy, post free, on request addressed to Messrs. Burton, Griffiths and Co., Limited.

Also a desk calendar from the Lea Recorder Company, Limited, 28, Deansgate, Manchester; a daily tear-off calendar from the Davenport Engineering Company, Limited, Bradford and Hull; and a weekly tear-off calendar from Messrs. John Fowler and Co. (Leeds), Limited, Steam Plough and Locomotive Works.

THE SAHARA EXPEDITION.—With reference to our article on page 13 *ante* giving an illustrated description of Mr. Citroën's Kegresse-Hinstin cars, news has been received that the expedition through the Sahara, from Touggourt to Timbuctoo, safely reached the latter place on Sunday morning, 7th inst., at 10 o'clock. The cars are stated to be in perfect condition and all the members of the expedition in good health.

WIRELESS TRANSMISSION OF OPERA MUSIC.—An interesting development has taken place this week in connection with the transmission of music by wireless telephony from the London Broadcasting Station, with which we dealt in our issue of December 1 last, on page 686. Arrangements have been made with the British National Opera Company for the broadcasting each evening of a part of the operas performed at the Covent Garden Opera House, and this will be continued for the remainder of the present season. With the co-operation of the Post Office and the engineer of the Opera House, four specially sensitive microphones have been installed in front of the stage of the theatre and connected to amplifiers below the stage, the current from the amplifiers being conducted to the transmitting set at Marconi House, Strand, by an underground cable. By this means the vocal and instrumental music, to say nothing of the applause of the audience in the theatre, is transmitted with the full power of the London Broadcasting Station, so that it can be picked up by anyone capable of receiving the normal transmissions from that station. The results have been exceedingly good, and they certainly reflect great credit on the enterprise and technical ability of the Broadcasting Company and their coadjutors.

INDUSTRIAL NOTES.

RAILWAY shop workers to the number of about 70,000 are affected by negotiations which were opened in London last week between the railway managers and representatives of the craft unions concerned. The subject dealt with, and to be decided, is the application by the railway companies for a further reduction of 6*s.* 6*d.* per week in the war bonus. The war bonus was in October last reduced by 10*s.*, as compared with a 16*s.* 6*d.* reduction which was applied to workers in the engineering trades outside the railways. In this respect, the railway workers are in a better position than the workers in the engineering industry generally. In defence of their claim the railway companies state that working expenses must be decreased in order to meet reductions in fares and in freight charges; they also lay stress upon the severe motor transport competition by road which they are having to meet particularly in Lancashire. The conference was adjourned until Tuesday next, to enable the craft unions to consider the case put forward by the companies. A subsequent meeting, however, was held between the railway managers and representatives of the National Union of Railwaymen, when the latter opposed the further reduction of 6*s.* 6*d.*, stating that a large number of shopmen had been working on short time, and that the earnings of semi-skilled and unskilled men had been barely at a subsistence level. The railway companies, for their part, intimated that they were prepared to discuss the setting up of machinery to improve the situation. No agreement was reached at this subsequent meeting and no arrangement seems to have been made for resuming negotiations.

Speaking at the twentieth annual general meeting of Baldwins, Limited, and dealing with the colliery section of the company, the chairman, Colonel Sir John Roper Wright, Bart., said the company were fortunate in that their collieries did not suffer any very serious physical damage through the strike, although their costs and developments were naturally affected for some time afterwards, through the expenditure which had to be incurred in repairing underground roads and workings. Outputs had increased since the strike, and, although this was a very satisfactory feature, yet, owing to the limited demand, due mainly in the case of the company to reduced steel production in South Wales, the increased quantities of coal placed upon the market had intensified competition, and very few collieries in South Wales had been able to work anything like full time. The demand for coal, therefore, was such that collieries could not be worked full time, and this irregular working kept up the cost of production and prevented the company from making the reductions in price which alone could stimulate the demand. They were for this reason, owing to this vicious circle, still a long way from being able to look upon a mining industry fully restored to health and vigour.

A further conference was held last week at Cardiff in the matter of congestion of coal-carrying ships in the docks. The employers urged that it was only by the introduction of a third shift that the coal export trade could be satisfactorily handled. The representatives of the men, on the other hand, stated that the congestion was due to lack of proper facilities and arrangements, and they asked that the facts should be investigated by a joint committee. The employers have accepted this suggestion and a committee has been appointed to report to a further conference. This means more parleys, and in the meantime there are probably numerous men in Cardiff who are in receipt of the dole at the expense of the working community. "The age that admires talk so much," said Carlyle seventy odd years ago, "can have little discernment for inarticulate work, or for anything that is deep and genuine." It may be that the arrangements at Cardiff are not as complete as would be desirable, but the unemployed might in the meantime make the best of them, such as they are. The talking could be continued the while.

Speaking last Monday at a meeting held in Birmingham of the National Union of Manufacturers, Sir Herbert Austin, M.P., compared the British and the American motor industries. He stated that in an effort to regain Colonial markets he found American selling prices remarkably low. Indeed prices to agents were less at the factory than British makers were paying for material for similar sized cars. Although American labour was highly paid, the employees in the United States worked at least twice as hard as was the practice here. Further, manufacturers of component parts were working on a low margin, some charges hardly covering the cost. He thought the British worker had something to learn in this respect. Probably 50,000 American motor vehicles would be imported to the United Kingdom this year, against a home production of 75,000, and he thought there was plenty of room for some protection before it was too late. Home manufacturers would probably have to combine to reduce the cost of production.

The ascertainment for the past quarter, published last week by the Cleveland Ironmasters' Association, certifies the average net selling price of No. 3 Cleveland pig-iron at 88*s.* 4*d.* per ton, or an advance of 2*s.* 9*d.* per ton on the price for the previous quarter. In accordance with the sliding scale arrangement, blast-furnacemen's wages will be advanced by $2\frac{3}{4}$ per cent., this raising them to $26\frac{3}{4}$ per cent. above the standard. Cumberland and North Lancashire blast-furnacemen's wages are increased by a quarter of 1 per cent. to $31\frac{3}{4}$ per cent. above the standard, on account of a rise of 6*d.* per ton in the average price of West Coast hematite for December to 92*s.* 3*d.* per ton. The new rate is applicable until the first full pay in March.

In our issue for November 10, on page 583, we called our readers' attention to an article in *Current Opinion*, the official organ of the Industrial League and Council, signed by a "Manual Worker," and complaining that the employer was not employing and was thus not fulfilling his function. We replied briefly to this argument. An "Honest Employer" has a note in the issue for the current month of the same journal, as follows: "'Manual Worker's' little homily on the duty of employers provokes an obvious retort. If the employer's job is to employ, so it is the worker's job to work. He has failed in hundreds of thousands of cases to do so. Ca' Canny has been more widespread than short time; strikes have been more numerous than lock-outs; sullen discontent among the workers has been more prevalent than indifference among employers; improved mechanical efficiency has been hampered by marked hostility on the part of workers. Neither side is free from blame, I admit, but passivity in the mass has had much more disastrous results than passive indifference in the individual. The repair of machinery is a simple job for hundreds of thousands of engineers; the understanding of the psychology of the worker in the mass is not given to one man in a million. Individually it is probably true that the worker is willing to co-operate with his employer; collectively he has shown little inclination to do so in recent years. Collectively he seems to regard the employer as some one to be thwarted, an enemy of the working class; individually he knows perfectly well that there is no such enmity. Let the workers see to it that their collective actions faithfully reflect their individual feelings, and they will find employers ready to welcome wholeheartedly any offer of co-operation."

The report of the South African Government Mining Engineer shows that the wages, of men employed at the gold mines in June, 1914, and in October, 1922, were as follows, per shift:—

	June, 1914.	October, 1922.
	s. d.	*s. d.*
Blacksmiths	20 1	20 3
Boiler attendants (firemen and cleaners)	14 11	15 8
Boilermakers	20 0	20 2
Carpenters	20 0	20 3
Drill sharpeners	20 6	20 7
Electricians	19 9	21 1
Engine drivers (winding)	21 8	22 5
Engine drivers (compressed air)	18 3	18 5
Fitters	20 0	21 0
Miners (contract)	30 6	31 1
Miners (day pay)	19 1	20 7
Pipemen and platelayers	18 7	20 3
Pumpmen	18 1	19 7
Timbermen	19 7	21 5

In their annual report for 1922, now issued, the British Manufacturers' Representatives' Association of South Africa (Incorporated), 96, St. George's-street, Cape Town, state that the conditions of trade during the past twelve months, from the point of view of representatives, have been the worst on record. At the end of 1921 it was anticipated more or less confidently that there would be an early return to normal conditions. The labour trouble that commenced on the Rand and culminated ultimately in the revolutionary strike upset all calculations. Eloquent testimony as to the slump that has taken place is to be found in the official figures with regard to insolvencies. In 1920 the total was 649 but in 1921 no less than 2,146, whilst during the first half of 1922 the number was 1,017; the deficiencies involved for the respective periods were 600,000*l.*; 1,950,000*l.* and 800,000*l.*

A general review of the financial and industrial conditions in the United States during the year 1922 is contained in the current issue of *The Guaranty Survey*, the monthly organ of the Guaranty Trust Company, of New York. It states that marked progress has been made in expanding the volume of industrial output in 1922. The average daily production of pig-iron in the United States for the first eleven months of this year was 59 per cent. above that for the corresponding months of 1921, and the production of steel ingots represented an advance of 71 per cent. The November production of steel was at a rate of about 39,500,000 tons per year, or approximately 75 per cent. of the estimated aggregate production capacity. The extraordinary activity in the building industry has been remarkably well sustained. As measured by contracts, a compilation by the Department of Commerce shows a gain of 51 per cent. in the first nine months of the year over the corresponding period last year. The automobile industry, contrary to the general expectation a year ago, has exceeded the previous record output of 1920, and the production for the entire year will probably be about 2,550,000 cars and trucks. The unexpected demand for automobiles constitutes, perhaps, one of the chief evidences of the broad foundation for the sustained upward movement in general business. The textile industries have made notable gains in the latter part of the year. Consumption of cotton and silk in October was greater than for any previous month in more than two years. Woollen manufacturing has also advanced, the consumption of wool by American mills was about 25 per cent. greater in the first ten months of the year than in the similar period last year. The report adds that the list of industries which have made significant recovery this year is a long one. In fact, there are few which have not shown material improvement. Besides the commodities already mentioned, those whose production has increased most include coke, copper, zinc, cement, brick, maple flooring and petroleum.

THE IRON AND STEEL INSTITUTE.—Volume cvi of the proceedings of this Institute has now appeared. It contain the papers which were read at the autumn meeting at York and the discussions thereon, together with abstracts on the iron and steel industries taken from journals and publications issued in every country of the world. Together with the indexes it covers 460 pages.

METALLOGRAPHICAL STUDY OF GALVANISED IRON.—A paper by Constructor-Lieutenant-Commander Y. Taji, read at the last autumn meeting of the Society of Naval Architects of Japan, gives an account of tests he has carried out with sherrardised materials. These tests and his metallographical examination of the specimens have led him to the conclusion that such materials are suitable for the inside fittings of ships and have the advantage of taking a bright polish; where sea-water attack is to be feared, they are liable to rust. Hot galvanised materials are more resistant, although their outward appearance is less pleasing than those which are sherrardised.

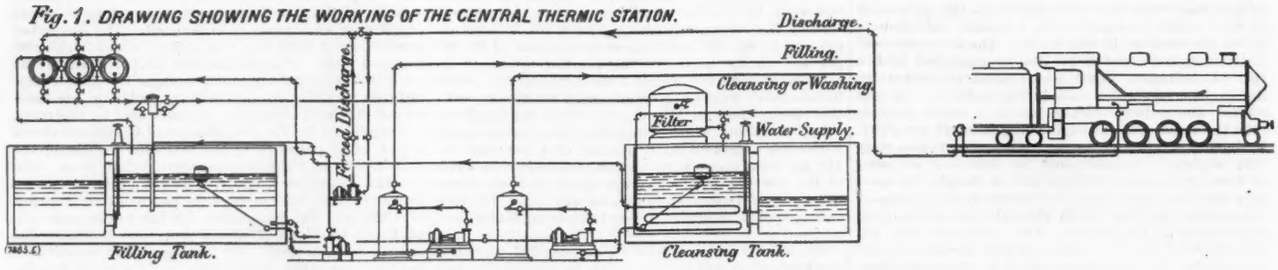
BULB AND REFLECTOR IN MINING LAMPS.—The bulb and reflector are the light-giving parts of the electric mine lamp. The bulb is designed to give a life of 200 hours to 300 hours, but some bulbs give a much longer life before actually burning out. Bulbs approved by the United States Bureau of Mines are tested to determine their practicability and efficiency and also for their safety in connection with the operation of the safety device in the head-piece used; bulbs other than those approved by some such tests should not be used, as the substitution might interfere with the action of the safety mechanism. The reflector on lamps should be designed to distribute the light from the head-piece evenly and at such an angle that the average person has a completely lighted area in which to work. A more concentrated lens gives a smaller circle of light but causes a dark area within it, and is harmful to the user's eyes. Frequently a lamp attendant or miner changes reflectors, a practice that should be discouraged, as any change in such lamp makes them of an unapproved lamp. Reflectors should be kept clean, but should not be treated with paint or special preparations by the lamp attendant.

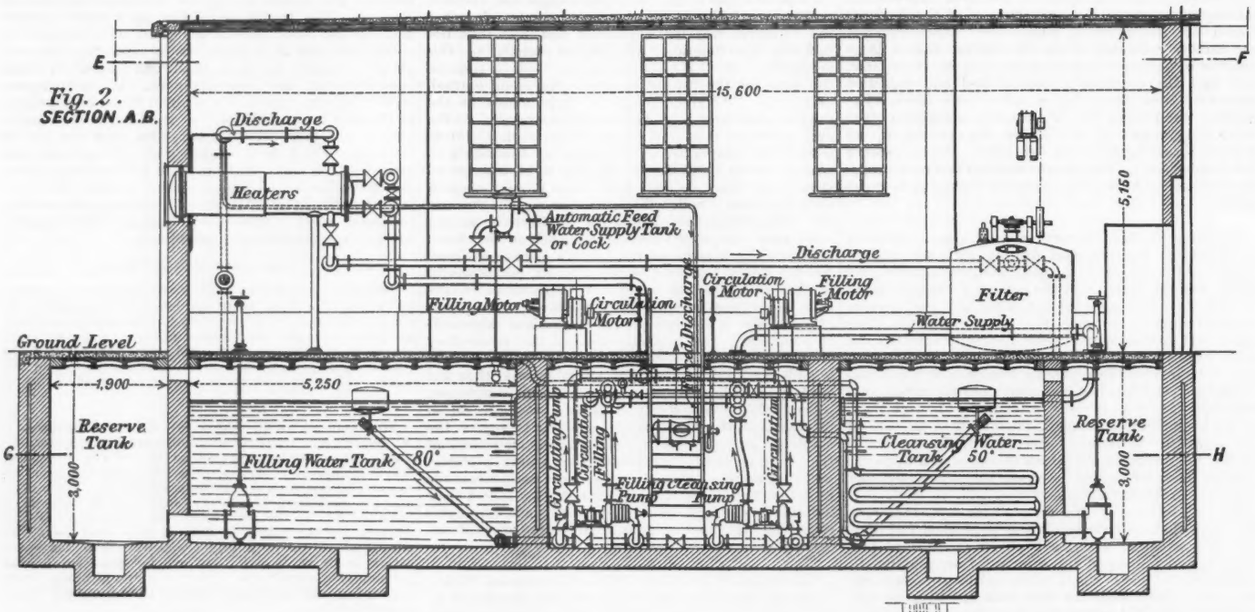
THE NORWEGIAN SALTPETRE INDUSTRY.—The report of the large Norsk Hydro Company states that the last financial year has been amongst the most difficult in the history of the nitrogen industry. The prices of agricultural produce receded very materially, in many cases even to a level approaching those of pre-war times. Buyers who generally cover their requirements in the autumn held back and only bought what they wanted well on in the spring of 1922. Prices kept falling the whole time. Although the visible unsold supply of Chili saltpetre at the end of the spring season amounted to 1,982,500 tons, against 1,219,000 tons at the same period of 1914, and in spite of the adverse circumstances referred to above, the Norsk Hydro succeeded in disposing of its entire production by the end of the spring season. The prices obtained were on a level with, and partly above, those current for Chili saltpetre, but were not in reasonable proportion to the cost of production. There have been considerable sales of saltpetre for industrial purposes and at somewhat higher prices than obtainable when sold for manure. It is hoped that the whole output in the future can be disposed of for industrial purposes. Prospects improved last autumn.

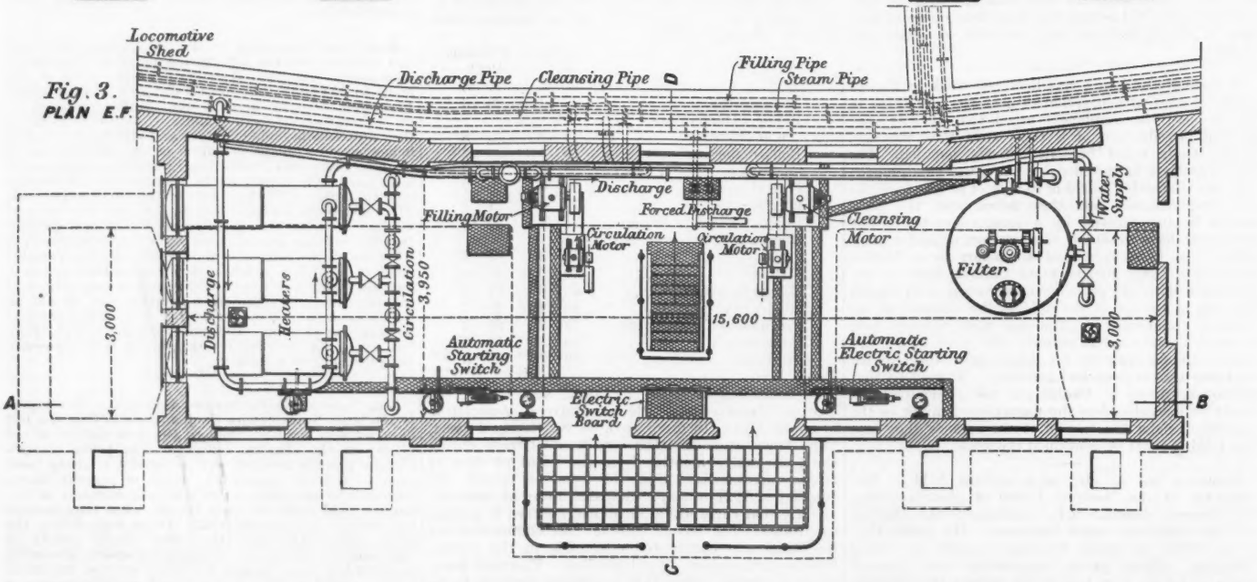
LOCOMOTIVE WASHING-OUT PLANT FOR THE ITALIAN STATE RAILWAYS.

CONSTRUCTED BY MESSRS. GIUSEPPE DE MICHELI AND CO., ENGINEERS, FLORENCE.

Fig. 1. DRAWING SHOWING THE WORKING OF THE CENTRAL THERMIC STATION.







DURING the meeting of the International Railway Congress in Rome last April many of the members took the opportunity of visiting the locomotive running-sheds at San Lorenzo, on the outskirts of the city. We dealt with this visit in our account of the proceedings of the Congress, and are now able to publish a detailed description of the locomotive washing-out and refilling plant which was one of the most interesting features of the equipment. The underlying idea of the plant is to recover the heat stored in the boilers of locomotives returning to the sheds, and to use it in the boilers of locomotives starting for their day's work. Thus, not only can steam be raised more quickly, but a useful saving of coal can be effected, the latter consideration being of great importance in a country like Italy where all coal has to be imported and where during recent years it has been at famine prices. Briefly stated the apparatus provides for the hot water from the boiler of an incoming engine being passed through a counter-current heat interchanger where its temperature is reduced from 275 deg. Fahr. to about 158 deg. Fahr. After filtration it is then collected in a large tank and used in its warm condition for washing-out purposes. The fresh water for filling the boilers passes first through coils in the tank referred to, and thence to another tank in which are submerged the coils carrying the hot water from boilers being emptied.

LOCOMOTIVE WASHING-OUT PLANT FOR THE ITALIAN STATE RAILWAYS.

CONSTRUCTED BY MESSRS. GIUSEPPE DE MICHELI AND CO., ENGINEERS, FLORENCE.

Fig. 4. PLAN G H

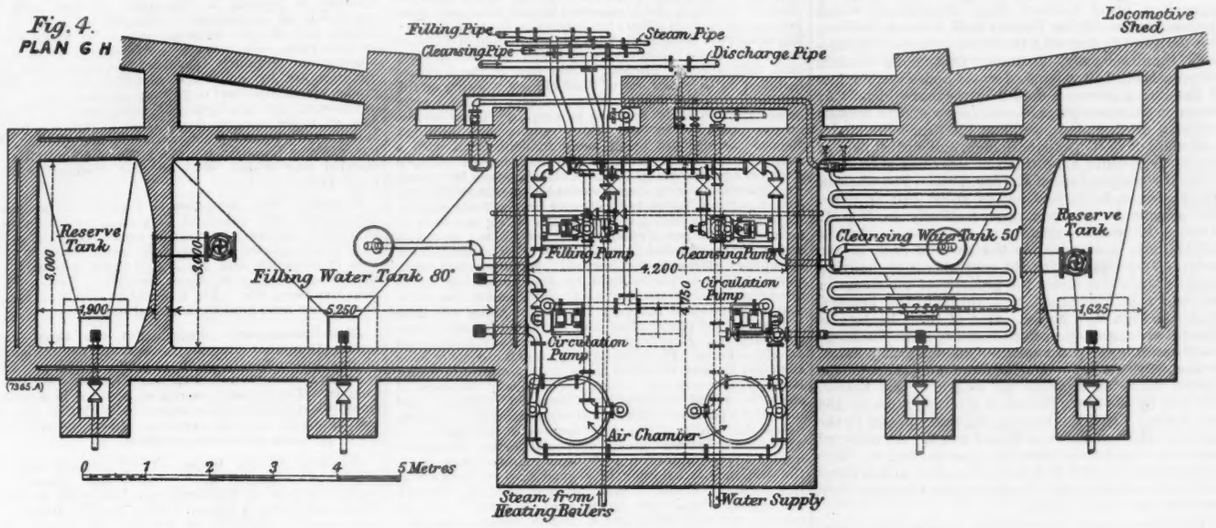


Fig. 5. SECTION C.D.

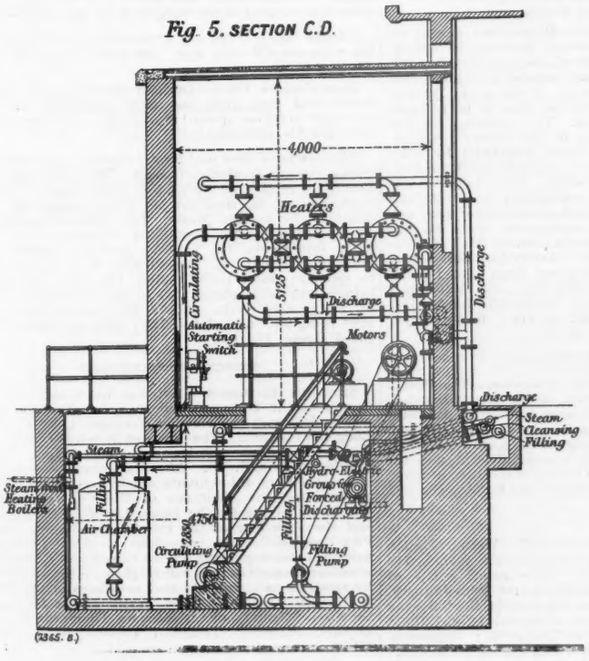


Fig. 6.

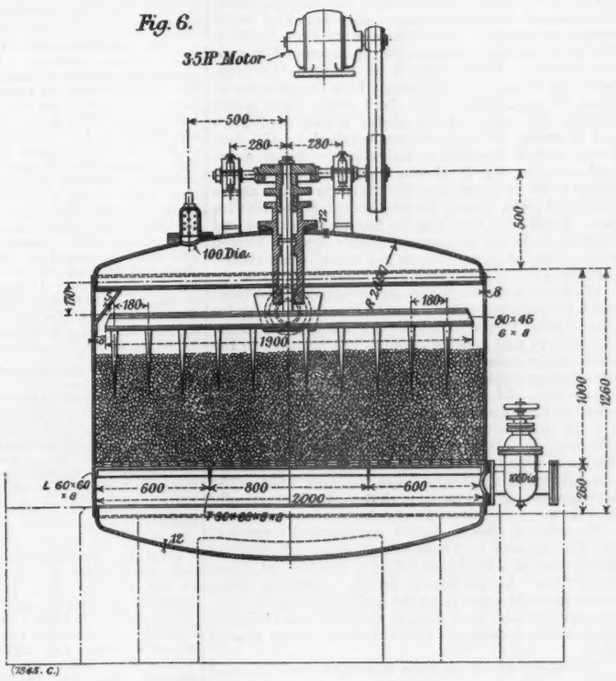


Fig. 7.

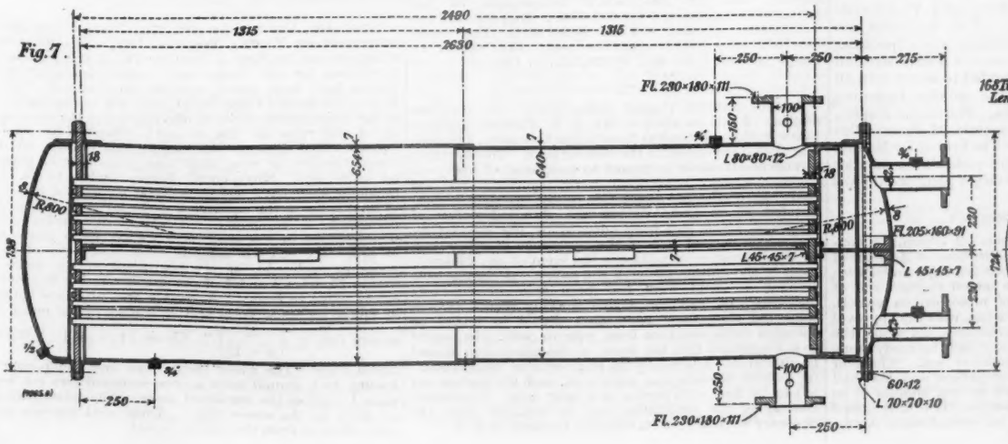
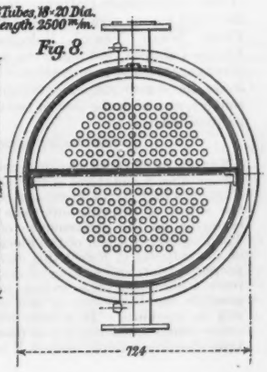


Fig. 8.



By these means its temperature is raised to about 80 deg. C. before it is finally pumped into the boilers of out-going locomotives.

Details of the plant installed at Rome are reproduced in Figs. 1 to 8, on pages 42 and 43, our engravings being redrawn from illustrations which appeared in the *Rivista Tecnica Delle Ferrovie Italiane*. It is designed to deal with the water from two locomotives simultaneously, assuming that these contain between them 880 gallons of water and 88 cubic feet of steam at a pressure of 42 lb. per square inch. At the same time two other locomotives would be washed out with filtered waste water at 120 deg. Fahr. under a pressure of 75 lb. per square inch, and a third pair of locomotives could have their boilers filled with clear water at a temperature of 176 deg. Fahr. The whole of this work can be carried out in about half an hour. The scheme is shown diagrammatically in Fig. 1. When a locomotive returns to the running shed a flexible hose is attached to the blow-off cock of the boiler, connecting it with the central heat-exchanging plant. The water under the pressure of the steam in the boiler is discharged first through the heaters, shown in Figs. 2, 3 and 5. One of these heaters is illustrated separately in Figs. 7 and 8. The discharge water entering at a temperature of about 275 deg. Fahr., surrounds the tubes and, after being compelled by the central baffle to traverse the length of the heater, leaves it by the lower branch at a temperature of 158 deg. Fahr. From the heaters, the water passes to the mechanical filter, shown in Figs. 2 and 3. An enlarged sectional view of the filter is given in Fig. 6. This apparatus is about 6 ft. 6 in. in diameter and is fitted with motor-driven rakes for stirring up the sand when the filter has to be washed.

The warm filtered water falls into the cleansing-water tank beneath where it remains until wanted for boiler washing purposes. As will be seen by Figs. 2 and 4, this tank contains a submerged pipe arranged in grid-iron fashion. Fresh water flows through this pipe, becoming warmed in its passage to a temperature of about 86 deg. Fahr. This fresh water then passes through the tubes of the heater shown in Figs. 7 and 8, where its temperature is raised to 176 deg. Fahr., and it is finally collected in the filling water tank seen in Fig. 2. Hence, whenever a locomotive boiler is to be filled there is ready for it an ample supply of clean water, already heated at no cost for fuel. Similarly, when a boiler has to be washed out there is ready for the purpose plenty of warm filtered water derived from emptying some other boiler previously.

Electrically-driven pumps are arranged in the basement between the fresh water and wash-water tanks. One of these serves to deliver the filling water to the locomotives and another supplies the pressure to the wash water necessary for washing out the boilers. Both pumps work normally at a pressure of 75 lb. per square inch, although the washing-out pressure can be raised to 120 lb. per square inch when desired. Should a boiler require to be emptied when it is not under pressure, an auxiliary pump is connected into the discharge pipe to provide sufficient head to force the water through the heaters and the sand filler. The arrangement of this pump is shown diagrammatically in Fig. 2.

Provision is also made for automatically regulating the amount of clean filling water admitted to the system in accordance with the quantity of water discharged. An electrically-driven circulating pump forces the cold water from the mains through the submerged coils and then through the cylindrical heaters, from which it descends into the filling water storage tank.

The plant which we have illustrated was installed by Messrs. Giuseppe De Micheli & Co., of 4, Via Strozzi, Florence. The system has proved so successful not only in saving fuel, but in facilitating and expediting the work of the running sheds, that the Administration of the Italian State Railways decided to adopt it in all the chief locomotive centres of the country, including Turin, Milan, Venice, Bologna, Florence, Naples, Reggio-Calabria, &c., and in several of these cities plants are already in operation. The firm of De Micheli & Co. have also prepared designs suitable for smaller centres, at which the cost of the larger plant would not be justified.

TRIALS OF MARINE OIL ENGINES.—A committee consisting of representatives of the Institutions of Mechanical Engineers and Naval Architects has been appointed with the object of carrying out tests on oil engines and of reporting on the performance of motor-driven vessels. The Engineer-in-Chief of the Fleet has, with the approval of the Admiralty, joined this committee. In scope, the proposed trials will include economy and thermodynamic tests ashore and manœuvring tests at sea. Wherever possible the behaviour of the propellers and the hull will be examined. It is intended to test engines of as many representative types as possible. It is anticipated that the first testing work will be carried out in April.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Improved conditions already prevail in the industries of Sheffield and district. The improvement is not general to all branches, but shows signs of gradual expansion and is expected to lead to a much more prosperous state of affairs by August or September next. Big strides are being made with the production of common soft steel, in the manufacture of which Sheffield pre-war took only a minor interest. Over half of the furnaces installed on the outskirts of Sheffield are working at full pressure, and the steady influx of new business gives promise of an early increase in output. There is also greater activity in the heavy engineering sections. Record castings are being made in connection with a large contract for a group of buyers overseas. Wagon works are getting really busy. Colonial orders have been supplemented during recent weeks by several substantial contracts from British railways and from private owners. Expansion is expected to run largely along the lines of an increased output of rolling-stock and railway materials and a heavy demand in connection with electrification enterprises at home and abroad. Sufficient has transpired at the inquiries held by the Electricity Commissioners in various parts of the country to show that at some date not very far distant there will arise a huge call for power plant and materials for electrification purposes. Improved conditions are fully maintained at rolling mills. Those supplying French engineers have sufficient business to enable them to work alternate weeks. Railway schemes are calling for a heavy tonnage of specially rolled materials. Makers of castings and machinery parts for agricultural engineers report brighter prospects, while automobile engineers are taking a considerably heavier tonnage of special steels. Sheffield's financial interconnection with firms mainly operating in the Midlands is bringing in a good deal of business in this respect. Prices of raw and semi-finished materials are mainly firm, with an upward tendency, but exceptions are still to be found, and in certain sections—notably building—negotiations are in prospect for a further reduction in operatives' wages.

South Yorkshire Coal Trade.—House coal is still an unsatisfactory market. Current business is mainly confined to moderate tonnages of best qualities, but the level of trade both on town and country account is well below the average for this period of the year. Householders who are holding off in the hope of lower rates are likely to be disillusioned. The tendency of the market is upward rather than in the reverse direction. The consumption of much larger quantities by coke ovens has caused a stiffening in prices of industrial fuel, best slacks being a good market. Exports of steam hards are maintained at a satisfactory level. Inland contractors are taking increased quantities of gas fuel. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 9*s.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

ROYAL SANITARY INSTITUTE CONGRESS.—The thirty-fourth Congress and Exhibition of the Royal Sanitary Institute will be held at Hull from July 30 to August 4 inclusive. A public meeting will be held in the Guildhall, Hull, on January 25, to inaugurate the local organisaton arrangements. Invitations to appoint delegates to the Congress have been issued to health authorities in Great Britain and to Dominion, Colonial and Foreign Governments.

COMPANY REGISTRATIONS IN 1922.—Messrs. Jordan and Sons, Limited, company registration agents, 116 to 118, Chancery-lane, W.C. 2, have issued a list of company registrations at Somerset House, from January, to December 30, 1922. From this we take the following figures:—Advertising, 108 for a capital of 337,070*l.*; electricity and gas, 236 for 7,649,456*l.*; engineers, 429 for 4,284,180*l.*; iron, brass, &c., 372 for 4,062,410*l.*; motors, 413, for 2,832,543*l.*; newspapers, 53 for 5,989,600*l.*; railways, 6 for 202,600*l.*; shipping, 219 for 3,559,100*l.*; textiles, 473 for 15,301,400*l.* The totals for 1922 were 7,852 companies and 119,078,233*l.*, as compared with 6,395 and 99,034,325*l.* in 1921.

DIESEL ENGINE USERS' ASSOCIATION.—At the last meeting of this association, Mr. A. E. Farrow, engineer to the Windsor Electrical Installation Company, Limited, was elected president for the ensuing year. The amended arrangements made in regard to insurance of heavy-oil engines against breakdown were reported, and the chairman of the Insurance Committee strongly recommended all members to use the standard policy of insurance which had been adopted by the association, and which carried with it the advantage of arbitration by the Insurance Committee in the event of any disagreement in the interpretation of the policy. A considerable amount of useful work had been done in collecting particulars of heavy-oil engine working costs. It was suggested that these particulars should in future be collected from members from year to year. In regard to a suggestion that the name of the association should be altered to "The Heavy Oil Engine Users' Association," no definite decision was arrived at, and the matter was left to be dealt with further at a later date. Particulars concerning the association can be obtained from the honorary secretary, at 19, Cadogan Gardens, S.W.3.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A moderately good business is passing in Cleveland pig-iron, and with expansion of operations confidently anticipated producers may shortly increase output by rekindling one or two more idle furnaces. At present there are 10 blowing on ordinary Cleveland pig-iron. The better qualities are by no means plentiful, but the inferior grades are in good deal more than ample supply. Values are moving upward, largely in consequence of increased cost of make due to dearer fuel. Market quotations stand:—No. 1 and siliceous sort, 96*s.* 6*d.*; No. 3 G.M.B., 92*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 83*s.*; and mottled and white, 80*s.*—all f.o.t. makers' works or f.o.b. Tees.

Hematite.—The cheapness of East Coast hematite in comparison with values of Cleveland pig-iron promises to attract custom. In normal times about 8*s.* used to be the recognised difference in price between mixed Nos. of hematite, and No. 3 Cleveland, whereas to-day the former are only 1*s.* above the latter, Nos. 1, 2 and 3 hematite being 93*s.* No. 1 hematite is put at 94*s.*, and 94*s.* 6*d.* has been paid for a named brand.

Blast-Furnacemen's Wages.—For the three months ending December 30 last the average net selling price of No. 3 Cleveland pig-iron was 88*s.* 4·74*d.* per ton, as compared with 85*s.* 7·16*d.* per ton for the previous quarter. The advance carries an increase in North-East Coast blast-furnacemen's wages of 2·75 (2¾) per cent., raising wages from 24 per cent. above the standard to 26·75 per cent. above the standard.

Ironstone Miners' Wages.—The Cleveland and North Yorkshire ironstone mine-owners, and miners' representatives met at Middlesbrough this week to consider wages and hours of labour. After lengthy discussion the mine-owners conceded an advance of 2 per cent. in wages. No settlement was reached on the question of increased working hours suggested by the employers.

Foreign Ore.—There is a firmer feeling in foreign ore, but sales are still very slow. Best rubio is quoted up to 23*s.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is scarce and very stiff, but local consumers are very reluctant to follow upward movement. Average descriptions are 31*s.* delivered.

Manufactured Iron and Steel.—Finished iron and steel quotations are decidedly stronger. Manufacturers have now quite good order books, and with prospects of more work coming in, they are no longer eager to secure contracts by cutting prices. The following are among the principal market quotations:—Common iron bars, 11*l.*; iron rivets, 10*l.* 7*s.* 6*d.*; packing (parallel), 8*l.*; packing (tapered), 11*l.*; steel billets, 8*l.* to 9*l.*, according to quality; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* to 9*l.* 5*s.*; steel angles, 8*l.* 15*s.*; steel rivets, 11*l.* 7*s.* 6*d.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets, 17*l.* 10*s.*

SILVANUS THOMPSON MEMORIAL LECTURE.—The first lecture at the Technical College, Leonard-street, E.C. 2, will be delivered on Thursday, February 1, by Sir Oliver Lodge, F.R.S., on "The Basis of Wireless Communication." The chair will be taken at 7.30 p.m. by Sir Charles Parsons, K.C.B. After the lecture a *conversazione* and re-union of old students will be held, guests will be received by the chairman of the College Delegacy, Mr. L. B. Sebastian, the Dean, Dr. W. Eccles, F.R.S. and the President of the O.S.A., Mr. W. M. Mordey. Past-Pres.I.E.E. A collection of Dr. Thompson's paintings and apparatus will be shown and a number of scientific demonstrations will be given in the laboratories by eminent past students and associates of the college. Early application for tickets (gratis) should be made to the Hon. Secretary of the Silvanus Thompson Memorial Lecture, Finsbury Technical College, Leonard-street, E.C.2.

STANDARD CONDITIONS FOR THE DESIGN AND CONSTRUCTION OF MARINE BOILERS, 1920.—The following modifications to Part I, Section IV of the Standard Conditions for the design and construction of Marine Boilers have been agreed upon by the Board of Trade, Mercantile Marine Department, with the representatives of the classification societies who assisted in the drawing-up of the rules on this subject:—Clause 2 to read: "*Single-ended Boilers.*—All single-ended boilers, 16 ft. mean diameter or over, shall have a glass water gauge on each side. Single-ended boilers under 16 ft. in diameter shall have one glass water gauge and one set of test cocks, or the equivalent of the latter," Clause 3, paragraph 1 to read: "*Double-ended Boilers.*—All double-ended boilers shall have a glass water gauge at or near each end, on opposite sides, and a set of test cocks at each end, or the equivalent of the latter." Clause 13, lines 6 and 7 of paragraph relating to size of safety valve to read: "Aggregate area of safety valves in square inches = Total heating surface of the boiler in square feet $\times \left(\frac{K}{p+15}\right)$." Clause 14 to read: "*Waste Steam Pipe.*—The waste steam pipe and the passages leading to it should have a cross-sectional area not less than 1·1 times the combined areas of the safety valves as given by the above rule." These modifications will take effect as from the current month.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There is little to report in connection with the Scottish steel trade this week as work is only now being resumed after the holidays, and some establishments will not be in operation before next week. Inquiries for the home market have not been over numerous of late, but with a hardening tendency of prices now in evidence all round there is the probability of more business coming along very soon. The foreign inquiry is a shade better and some improvement from that quarter is expected also. In the meantime there is little doing as consumers are slow to make any definite move. For the present the quotations are nominally without change.

Malleable Iron Trade.—While the outlook is better in the malleable iron trade of the West of Scotland, it cannot be said that it has made itself felt so far. A few of the works made a start this week, but little fresh business had made its appearance and managements are not anticipating any great inrush of orders for a week or two yet. The general inquiry is hopeful, but actual bookings are what are required. Prices are steady round 10*l.* 10*s.* per ton, delivered Glasgow, for "crown" bars.

Scottish Pig-Iron Trade.—The pig-iron producers of Scotland are calmly waiting on the position of things getting better, but so far there has been little disposition shown by consumers to enter the market. Orders given out since the end of the year do not amount to any large tonnage and stocks on hand are quite ample for immediate requirements. The blowing-in of furnaces proceeds slowly and no rush in that direction is looked upon as necessary. Producers are anticipating a better demand for hematite iron as soon as the shipyards get into their stride. Prices to-day are as follow:—Foundry iron, No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, on trucks at makers' yards; and hematite, 5*l.* 7*s.* 6*d.* per ton delivered at the steel works.

Scottish Pig-Iron Shipments.—The export of Scottish pig-iron from Glasgow Harbour for the week ending Saturday, January 6, was very satisfactory for the opening week of the year, and totalled 1,219 tons. Of that quantity no less than 1,177 tons went foreign and the balance of 42 tons went coastwise. For the first week of last year the export was only 10 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Shipping has arrived more freely during the last few days, and the result is that concessions are not now so freely available for spot and prompt loading as was the case last week. On paper practically all the collieries are fully booked up, but difficulties created by shipping getting out of position and delay by the railway in clearing stocks from the pits is still the cause of weak spots for quick loading. The general inquiry is active from all directions and there are a number of orders in the market for quantities ranging from 5,000 tons to 100,000 tons. The United States are still heavy buyers, though a large amount of business has already been transacted, as will be gathered from the fact that last week 23 vessels to carry 133,000 tons of Welsh coal were reported as chartered on the open freight market, while there still remained quite another dozen orders for ships. The question of extending the working hours at the docks, with a view to minimising the delay to shipping experienced under the present two-shift system, is to be considered by a joint committee representing the employers and the workmen. This decision was reached at a conference of all the interests when Mr. J. H. Vickery, chief docks manager for South Wales, gave specific cases in which delays could have been obviated had there been a more elastic system in operation. Mr. Robert Williams, general secretary of the National Transport Workers' Federation, on behalf of the trimmers and tippers, stated that the men were not prepared to extend their working hours unless they were agreed that it was necessary. He suggested that a committee of investigation should be appointed to examine all the facts and report to another conference. The employers recognised the fairness of this proposal and agreed to it on the understanding that there should be no delay in going into the question. Eventually a joint committee of six from each side representing the railways, docks, shipowners, coal owners, exporters, the coal trimmers and tippers was appointed.

Exports.—Exports of coal as cargo last week amounted to 478,000 tons, compared with 326,000 tons in the previous holiday week. Of the total, 152,000 tons went to France, 35,000 tons to Italy, 71,000 tons to South America, 33,000 tons to Spain, 11,000 tons to Portugal, 15,500 tons to Greece, 38,500 tons to British coaling depots, 10,000 tons to the United States and 110,300 tons to other countries, which included 5,800 tons to Bremerhaven, 9,900 tons to Hamburg, 17,000 tons to Ghent, 16,000 tons to Antwerp, 5,000 tons to Amsterdam, and 22,000 tons to India. For forward loading prices are firm on the basis of 28*s.* for best Admiralty large, 26*s.* to 27*s.* for Monmouthshire large, and 15*s.* to 18*s.* for smalls.

Iron and Steel.—The export demand for Welsh tinplates is expanding and prices are steady round the recent figure of 20*s.* 6*d.* to 21*s.* for the standard box. Shipments of tinplates last week amounted to 5,235 tons, compared with 953 tons in the previous holiday week, black plates 2,007 tons against 906 tons, galvanised sheets 46 tons against 128 tons, and other iron and steel goods 3,134 tons against 1,608 tons.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 12, at 7 p.m., Storey's Gate, St. James's Park, S.W. 1. Informal Meeting. Subject, "Technical Journals and their Use to the Engineering Profession." Discussion to be opened by Mr. A. P. Bale.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 12, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Paper, "Transient Phenomena Arising in Transformers from Switching Operations," by Mr. S. A. Stigant.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, January 12, at 6.30 p.m., at the Engineers' Club, Coventry-street, W. Discussion on "Gliding" and "Gliders at Itford."

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 12 and 26, at Bolbec Hall, Newcastle-on-Tyne. "Review of Different Types of Marine Internal-Combustion Engines." Contributions by Sir W. G. Armstrong, Whitworth and Co., Limited; William Doxford and Sons, Limited; Hawthorn, Leslie and Co., Limited; Palmers Shipbuilding and Iron Company, Limited; Scott's Shipbuilding and Engineering Company, Limited; Swan, Hunter and Wigham Richardson, Limited; and Vickers, Limited.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Friday, January 12, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. Lecture, "Automatic Temperature Control," by Mr. B. R. Wingfield, Ph.D., M.I.E.E.

THE INSTITUTION OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, January 13, at 4 p.m., at the Grand Hotel, Manchester. Paper on "The Evolution of the Foundryman," by Mr. W. H. Sherburn, F.R.S.A.

THE INSTITUTION OF CIVIL ENGINEERS, NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, January 15, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-on-Tyne. Paper by Mr. J. W. Goldson, M.Inst.C.E., on "The Reconstruction of the South Dock Entrance Gates at Seaham Harbour."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 16, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Discussion on "The Need for Suitable Training in Illuminating Engineering," by Mr. C. E. Greenslade and Mr. J. E. S. White.

THE INSTITUTE OF TRANSPORT.—Tuesday, January 16, at 5.30 p.m., in the Lecture Theatre, Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Lecture to the Graduates and Students by Mr. H. C. Gunton, M.B.E., on "The Employment of Transport in Relation to Post Office Operations."

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, January 16, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Paper on "Plastic Flow in Metals," by Professor C. D. Desch, D.Sc., Ph.D.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 16, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. Papers to be discussed: "The Longitudinal Strength of Bulk Oil Carrying Vessels," by Mr. T. R. Thomas, B.Sc., and Mr. James Turnbull; "Stability of Self-Trimming Types of Cargo Steamers," by Mr. George Nicol. Paper to be read: "The Development of the Sulzer Diesel Engine," by Engineer Lieutenant-Commander L. J. Le Mesurier, R.N.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 16, at 6 p.m., at Great George-street, S.W. 1. Ordinary Meeting. Paper to be submitted for further discussion: "Twelve Years' Operation of Electric Traction on the London, Brighton and South Coast Railway," by Mr. Henry Walter Hungerford Richards. Wednesday, January 17, at 6 p.m.: Students' Meeting. Vernon-Harcourt Lectures, "Foundations in Dock and Harbour Works." (Lecture I), by Mr. Thomas Ryder Wilton, M.A., M.Inst.C.E.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, January 16, at 3 p.m., at Albemarle-street, Piccadilly, W.1. Afternoon Lectures, "Semi-Permeable Membranes and Colloid Chemistry: (1) The Theory of Ionic Equilibria and Semi-Permeable Membranes," by Professor F. G. Donnan, D.Sc., F.R.S., M.R.I. Thursday, January 18, at 3 p.m., (1) "The British Soldier and the Regimental Officer at the Close of the Napoleonic War," by the Hon. J. W. Fortescue, C.V.O., LL.D. Saturday, January 20, at 3 p.m.: "Speech Rhythm in Vocal Music" (Lecture 1), by Sir Walford Davies, Mus.Doc., LL.D. (Illustrations by members of the Temple Choir.) Friday, January 19, at 9 p.m.: Evening Discourse will be delivered by Sir James Dewar, LL.D., D.Sc., F.R.S., M.R.I., on "Soap Films as Detectors: Stream Lines; Vortex Motion and Sound."

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, January 17, at 7.30 p.m., at 49, Cromwell-road, South Kensington, S.W. 7. Annual General Meeting. Address on "Aurora and Allied Problems," by Mr. Charles Chree, Sc.D., LL.D., F.R.S., President.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 17, at 8 p.m.: Ordinary Meeting, "Hygienic Methods of Painting—The Damp Rubbing-down Process," by Mr. C. A. Klein. Mr. T. M. Legge, C.B.E., M.D., H.M. Chief Medical Inspector of Factories, will preside. Friday, January 19, at 4.30 p.m.: Indian Section, "A Clash of Ideals as a Source of Indian Unrest," by the Right Hon. The Earl of Ronaldshay, G.C.S.I., G.C.I.E., late Governor of Bengal. The Right Hon. Viscount Peel, G.B.E., Secretary of State for India, will preside.

THE NORTHAMPTON ENGINEERING COLLEGE, ENGINEERING SOCIETY.—Thursday, January 18, at 5.30 p.m., at the College, St. John-street, E.C. 1. Paper by Mr. J. W. Perkins, "The Gyro-Compass."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 18, at 6 p.m., in the Lecture Theatre of the Institution, Victoria Embankment, W.C. 2. "Works Production," by Mr. G. H. Nelson.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 19, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Laminated Springs," by Mr. T. H. Sanders.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 19, at 6 p.m., at Storey's Gate, St. James' Park, S.W. 1. A symposium of papers on "Indicators." Four papers are to be read, as follows: "The Problem of the Engine Indicator," by Mr. L. Pendred; "A New Form of Optical Indicator," by Professor Burstall; "A Micro-Indicator for High-Speed Engines," by Mr. W. G. Collins; and "R.A.F. Electrical Indicator for High-Speed Internal-Combustion Engines and Gauge for Maximum Pressures," by Mr. H. Wood, R.A.F.

OIL ENGINE NOMENCLATURE.

IT will be remembered that at the Lincoln meeting of the Institution of Mechanical Engineers, in 1920, a suggestion was made that the claims of Mr. H. Akroyd-Stuart as the pioneer of the modern heavy-oil engine should be given preference to the adoption of the term semi-Diesel. A committee was subsequently appointed by the Institution to consider the question and its report has now been published. The following are the findings of the committee:—

1. The committee has given consideration to various suggestions and schemes of nomenclature emanating from the chairman, individual members and from its sub-committee; to correspondence and pamphlets addressed to it by Mr. Herbert Akroyd-Stuart; to dossiers submitted by the Admiralty and the Department of Scientific and Industrial Research; to representations from the British Engineering Standards Association; and to replies to inquiries, made on its behalf by Mr. Pendred, as to the existence or otherwise of approved nomenclature of oil engines by engineering Institutions in France and in the United States of America.

2. The committee is of the opinion that the modern oil engine, as distinct from the automobile type of liquid fuel engine, has been evolved mainly from the principles enunciated by Mr. Herbert Akroyd-Stuart in his patent No. 7,146, of May 8, 1890, and, as embodied in the engine constructed at Bletchley (Buckinghamshire) and tested by Professor William Robinson, a member of the committee, in February, 1891. Professor Robinson referred to this engine in detail in a paper, "The Uses of Petroleum in Prime Movers," read on April 29, 1891, and subsequently published in the Journal of the Society of Arts. This "Akroyd" engine is the prototype of those in which the liquid fuel is introduced into a compressed or partially compressed charge of air, and which do not need an extraneous source of ignition. In this respect the "Akroyd" engine anticipated the engine subsequently evolved in Augsburg, Germany, by the Maschinenfabrik Augsburg Nürnberg from the original proposals of Rudolph Diesel in 1893 and described by H. Ade Clark, in his paper "The Diesel Engine," read before the Institution at the meeting in Leeds in July, 1903. It may thus be said that the pioneer work of Herbert Akroyd-Stuart has been adversely cloaked by nomenclature.

3. In the development of modern oil engines, departures have been made both from the "Akroyd" and the "Diesel" original principles, and to designate these by inventors' names would be misleading and depreciative of the work of those to whose efforts the recent successes achieved have been due. The various types of engines merge so intricately that arbitrary grouping for the purposes of nomenclature would be unsatisfactory. For commercial exploitation, trade names cannot be dispensed with and, after all, these are usually sufficiently distinctive for general use

4. The committee considers that the term "Semi-Diesel" as applied to oil engines is subversive of the fact that this type of oil engine is a British production and an evolution from the "Akroyd" engine.

5. After careful consideration, the committee has been forced to the conclusion that an extended classification would be of little value, and that it is improbable that any system of nomenclature could be devised to cover all divergent points of detail and to meet practical requirements.

WEST OF SCOTLAND ELECTRICITY DISTRICT.—The Electricity Commissioners have extended the time for representations and proposals from parties concerned in connection with the proposed West of Scotland Electricity District. Objections or proposals may now be made up to June 30 next.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The annual dinner and reunion of the Institution will be held at the Hotel Cecil, Strand, W.C., on Tuesday, February 6, under the presidency of Mr. Frank Gill, supported by the council. Application for tickets should be made not later than Thursday, February 1.

UNIVERSITY OF LONDON.—Professor Miles Walker, M.A., D.Sc., Professor of Electrical Engineering, University of Manchester, will give four lectures on "The Control of the Speed and Power Factor of Induction Motors" at the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, W.C. 2, at 5.15 p.m. on Wednesday, February 21, Monday, February 26, Wednesday, March 14, and Wednesday, March 21.

THE MANUFACTURE OF SPIRAL BEVEL GEARS AT THE WORKS OF MESSRS. E.N.V. MOTORS, LIMITED.

(*For Description, see Page* 32.)

FIG. 10. GROUP OF GLEASON ROUGHING MACHINES.

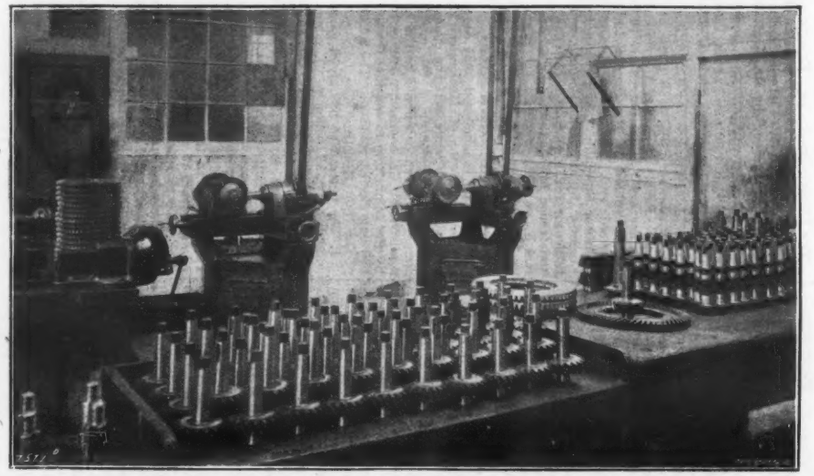


FIG. 11. TESTING DEPARTMENT.

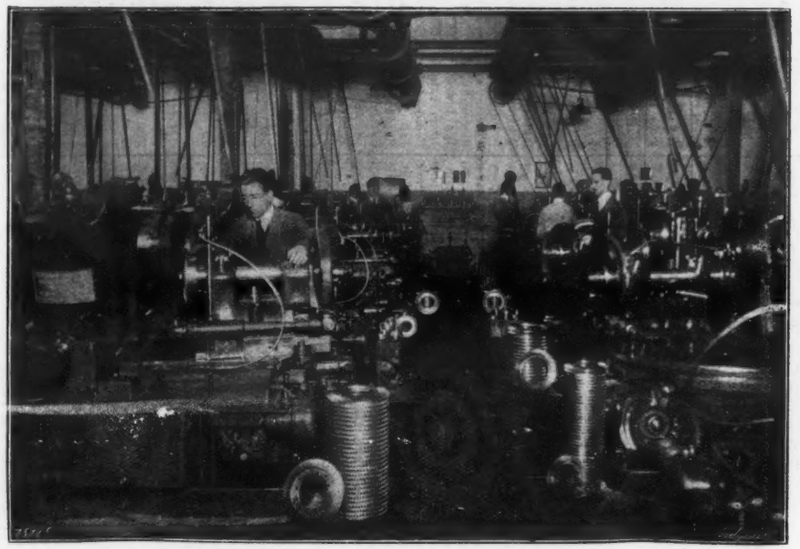


FIG. 12. GROUP OF GLEASON GEAR GENERATING MACHINES.

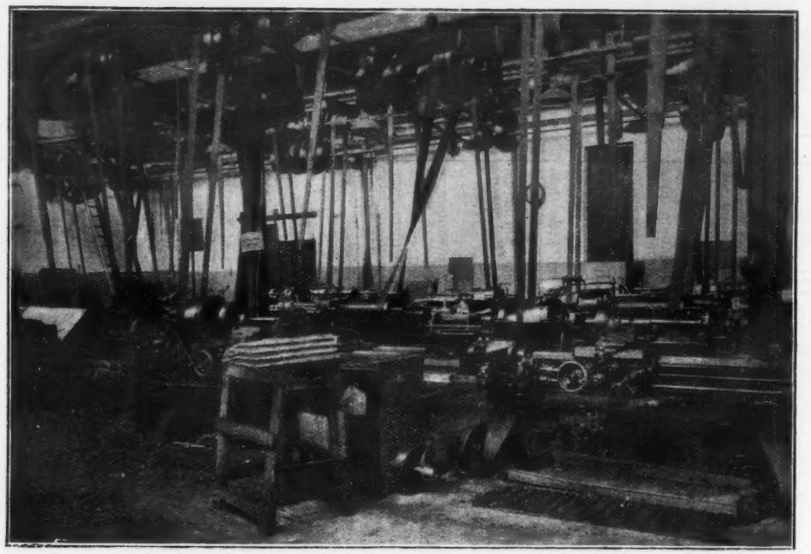


FIG. 13. TURNING BLANKS FOR BEVEL GEARS.

Fig. 12. Group of Gleason Gear Generating Machines.

Fig. 13. Turning Blanks for Bevel Gears.

GENERAL ARRANGEMENT OF THE GEARED TURBINE MACHI[N]E

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., [L]IMITE[D]

(For Description see [P]

Fig. 25

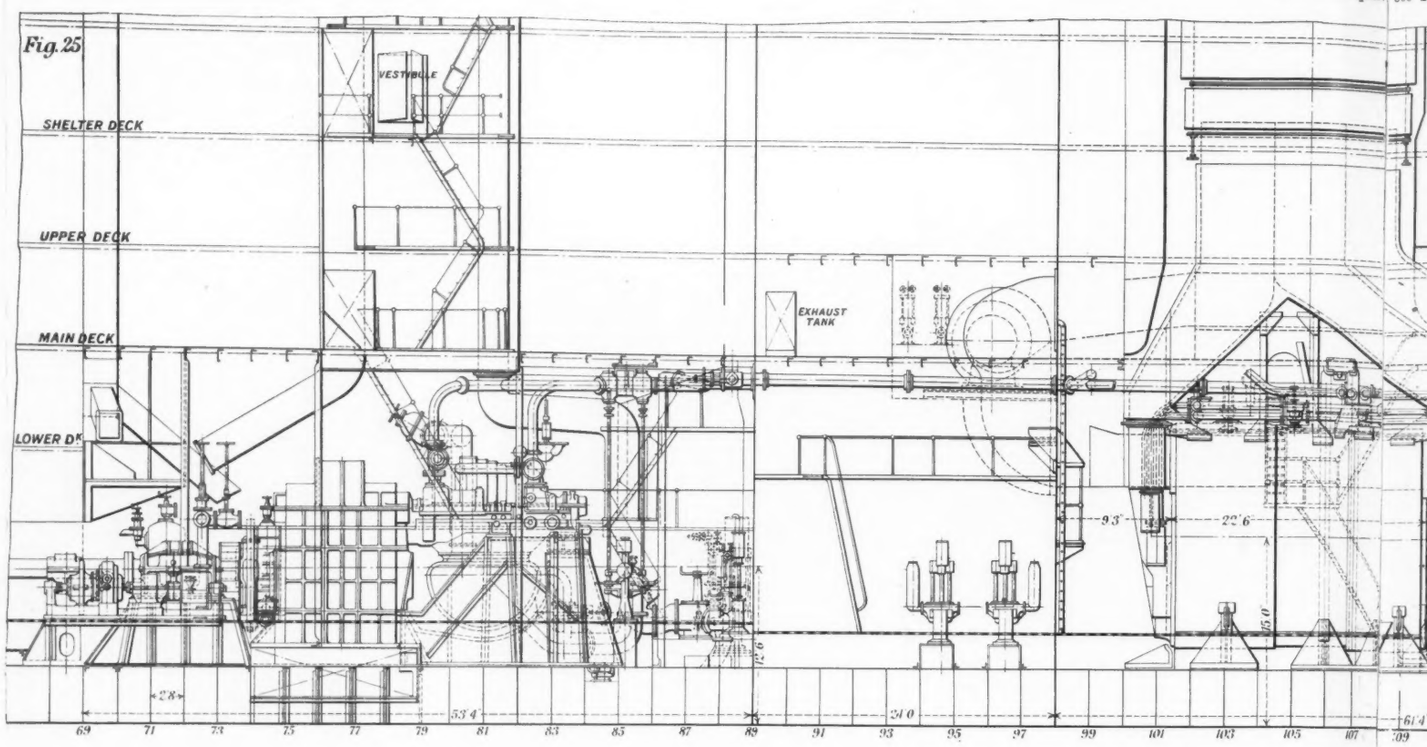
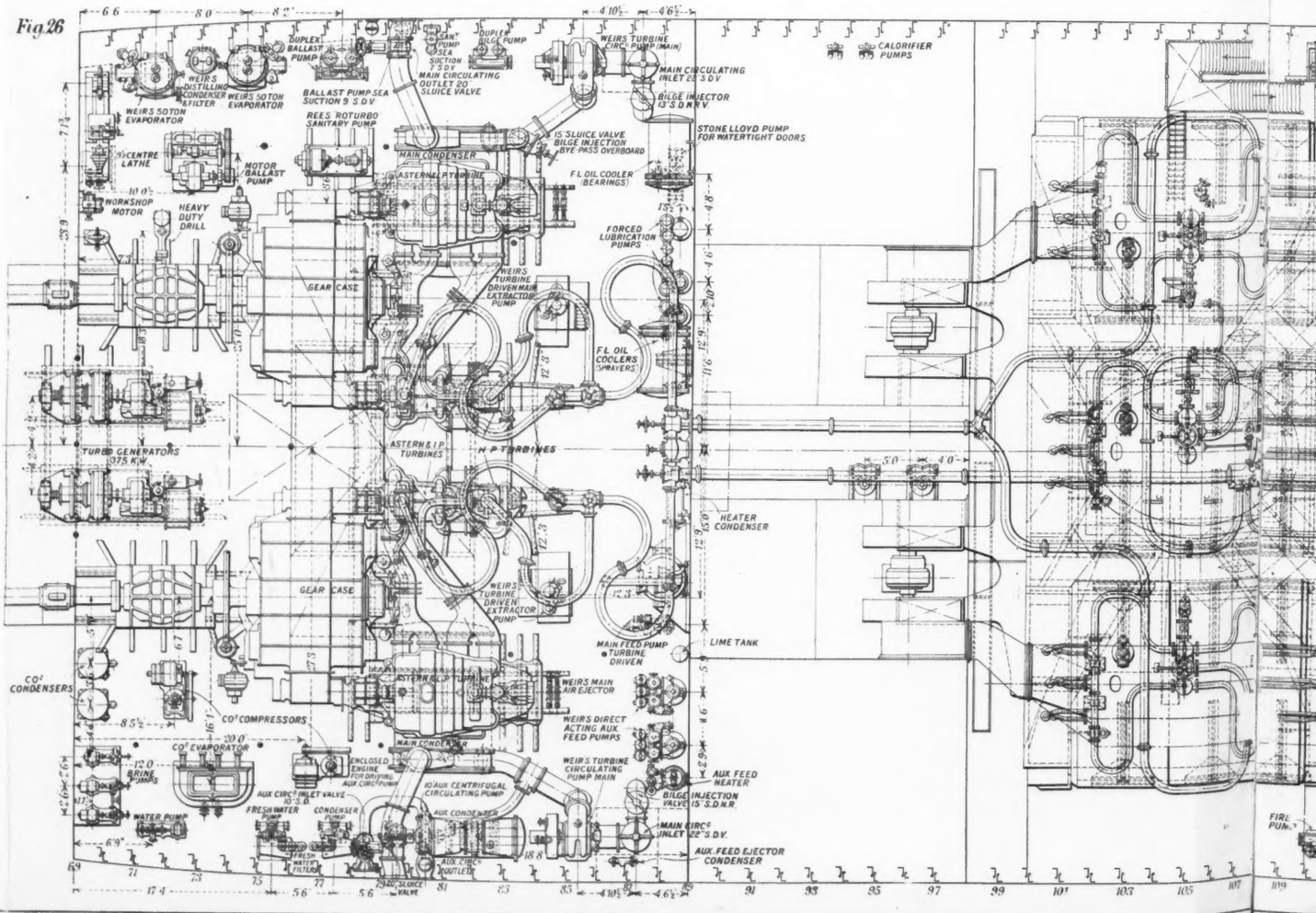


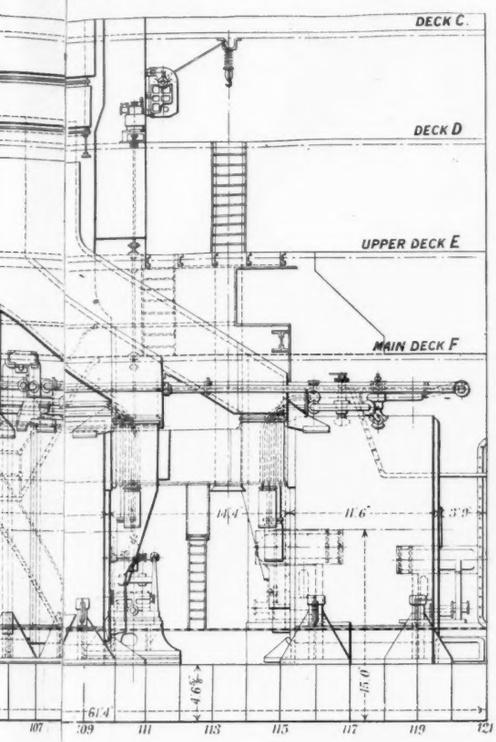
Fig. 26



...CHINERY AND BOILERS OF THE CUNARD STEAMER "SAMARIA."

...D CO., LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

(Description see Page 40.)



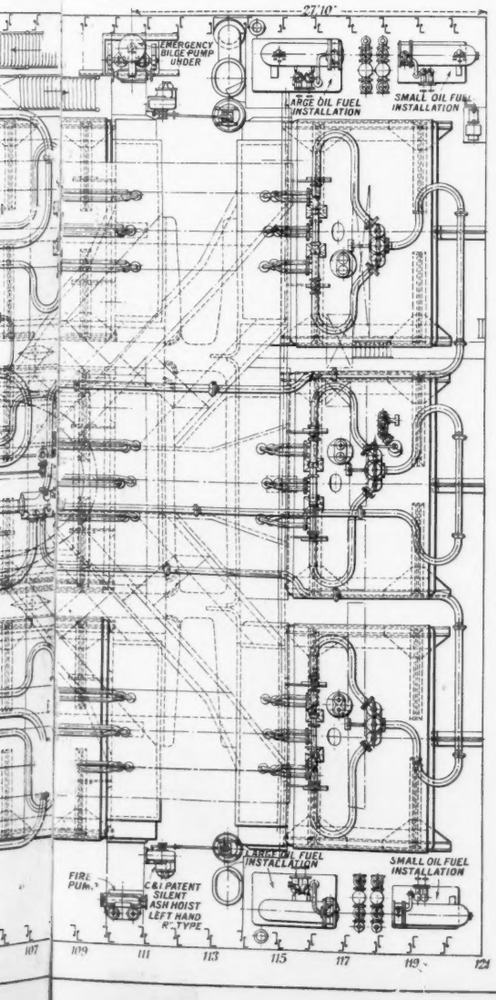


Fig. 27 SECTION AT 73 LOOKING AFT.

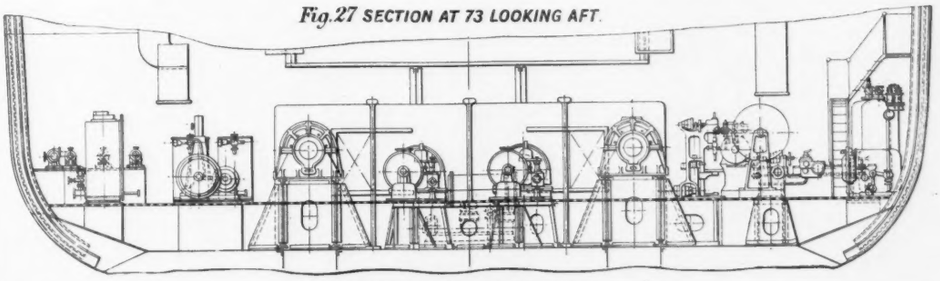


Fig. 28 SECTION AT 81 LOOKING FORD

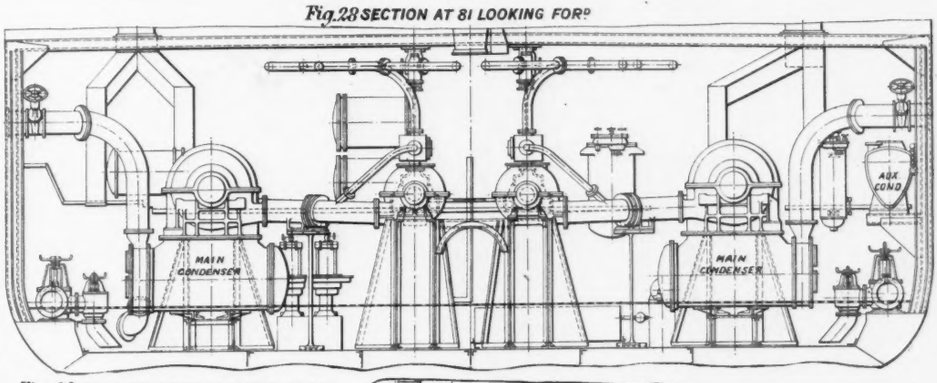


Fig. 29. SECTION AT 77 LOOKING FORD

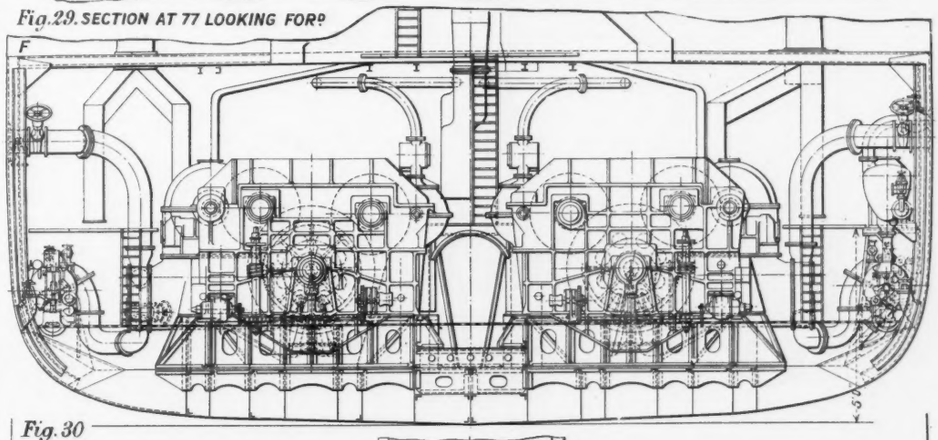
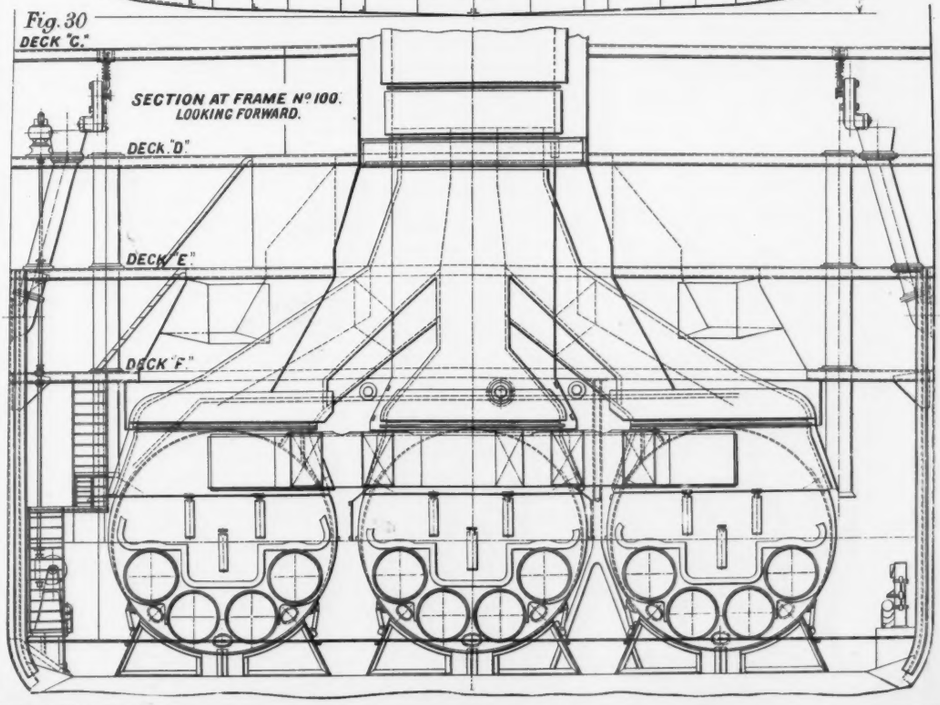


Fig. 30



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ENGINEERING.

FRIDAY, JANUARY 12, 1923.

THE DIFFICULTIES OF PAYMENT BY RESULTS.

STATED as a general proposition, no sensible man will deny that the reward for labour ought to be proportional to the value of the work performed. This, indeed, is the basis of the argument for payment by results, which is not only fair in principle between man and man, but encourages the individual worker to utilise his energy and intelligence primarily for his own benefit, but equally certainly to the advantage of the community as a whole. In many trades, some of them amongst the most highly organised, payment by results in the form of piece-work, is the standard method of remuneration, and is satisfactory alike to the employers and workers. In such trades it will generally be found that not only are the operations simple, repetitive and easily defined, but that both the employers and the workers' organisations are strong enough to negotiate prices which shall be mutually fair, and to prevent instances of unwarranted price-cutting which have done so much to make the piece-work system suspect in the past.

No one who has not had practical experience of the matter can fully appreciate the extraordinary difficulties of applying a fair piece-work system to work in which methods and operations are not absolutely standardised. Even on straight repetition machine work, it was found during the war that an operator, working with absolute certainty that his prices would not be cut and that nothing but good to himself and his fellows could result from his efforts, might acquire in time an almost incredible expertness at his job. His output would rise week by week for months, so that what was a fair piece-work price when he started, eventually brought him in an income which a works-manager might envy. No one, however conversant with the possibilities of machine tools could foresee these things, and even if the ultimate output of an expert man could have been predicted, no piece-work price based on such an estimate would have been accepted to start with. Human nature is such that the initial price must be sufficient to make the operator believe that reasonably hard work will ensure him an income greater than that of day-work, or he will never really find out what he can do. Much which might be called "limitation of output" is due to an honest belief that no greater amount of work can be efficiently performed. It was not uncommon in shell-factories, where the men had every inducement to do their utmost and were entirely willing to do it, to find an average level of production maintained for a long time in respect of a certain operation. Then some one man would start forging ahead, and convinced thereby that greater output was possible, the whole section would soon show a material improvement.

It may be argued that if the employer can afford to pay a piece-price when originally agreed to, there is no reason why he should seek to reduce the price after the workman has become expert enough to earn a large income at it. The work costs the employer no more in direct labour charges than it previously did, and the fixed charges per piece are much reduced owing to the larger output for the same expenditure on capital, management and maintenance accounts. These standing charges in the aggregate are usually much higher than the direct labour costs, so that even with a fixed piece-work price, the total cost of the article is largely reduced by the extra exertions of the piece-worker. The latter realises this quite well, and he is, therefore, liable to believe that any cut in his piece-prices is dictated merely by an unconscionable greed or an absurd jealousy of his earnings on the part of the employer. Such ideas, we need not say, do not cross the mind of any reputable employer. The more money his workmen can earn, the better he is pleased, particularly when their prosperity is contributory to his own. The employers' difficulty with regard to very high piece-work earnings on particular jobs is of another kind altogether. Such earnings cause so much discontent amongst those who have less lucrative occupations, or who are not doing piece-work at all, that some adjustment becomes necessary in the interests of peace and harmony in the works. This, in its turn, is liable to have effects as harmful, even if not so obviously so, as the inequalities it is intended to prevent. The workers lose confidence in the integrity of the management, they look upon piece-work as a means of securing enormous outputs from them at little more than daywork earnings, and from motives of self-protection they may deliberately refrain from doing their best in order not to "spoil the job," by bringing about a reduction in their piece-rates.

The extreme difficulty of fixing piece-work prices, on a fair and enduring basis, especially in engineering works, where the variety of operations is very great, has led to attempted solutions of the problem of payment by results in other directions. To avoid unfair inequalities between man and man, some people have favoured schemes in which bonuses are payable to whole groups of workers, or whole departments in accordance with the aggregate output of the men concerned. Group systems of this kind, however, suffer from the defects of every compromise. If the groups are small enough for every man to feel that his earnings are materially affected by his own exertions, they must be so numerous that trouble arises on account of inequality of earnings between different groups. If, on the other hand, they are large enough to minimise this difficulty, then each man's earnings are so little dependent upon his individual work that he has small inducement to put forth his best efforts. Experience during the war showed a noticeable increase in the total output of a group of men, when payment was changed from a group bonus system to individual piecework.

To avoid the difficulties inherent in straight piece-work, much ingenuity has been spent in devising alternatives which should retain the valuable feature of individual reward for efficiency while eliminating the temptation of the employer to cut prices, whether on account of rapacity or for the more usual motive of correcting gross disparities in earnings. The so-called "premium bonus" systems, of which the Rowan and the Halsey may be taken as typical, are the outcome of these attempts. In both of them a standard time is set for the performance of a given job. If the workman completes it in less, under the Halsey system he receives as a bonus half the money represented

by the saving of time he effects, while under the Rowan system his hourly rate while he is working, is increased in the same proportion as the time saved bears to the time allowed. If, for example, a man is allowed 100 hours to do a job which he completes in 80 hours, under the Halsey system, he would be paid as if for 90 hours' work, while under the Rowan system he would be paid as if for 96 hours' work. The latter system has the advantage that the employer can safely give a pledge that no matter how the time may be set in the first instance, it shall never be altered, and this indeed is generally guaranteed. The nature of the Rowan system is such that under it the earning capacity of the workman is automatically limited to double his hourly rate. If, for instance, the job mentioned above were only to take one hour for its completion, and so bad an estimate can hardly be assumed to occur in actual practice, the workman would only receive payment for 1·99 hours, during the hour he worked on it. Thus, for such savings in time as may reasonably be effected, the worker is quite well rewarded, while no matter how extravagantly the standard time may be set, the employer is safeguarded against payment of more than double-time to any workman.

It might be thought that such a system as the Rowan, which appears to avoid the outstanding difficulties of straight piecework, would meet with general approval both by workmen and employers. This, however, is not the case by any means. In the first place, the workmen find it very difficult to understand and are, therefore, suspicious of it, in the same way that people of presumably much better education are antagonised by the much simpler matter of the therm basis of charging for gas. Even when understood, however, the system is viewed with disfavour because the greater the output in a given time the less the earnings per piece made. The men naturally argue that if the employer can pay, say, twenty pence for an article when an hour is spent in making it, he is not justified in paying only fifteen pence for the same work when performed in half-an-hour. In the second case the workman is certainly earning time and a-half, as against time rate only in the former, but nevertheless he feels that he is labouring under an injustice, and he regards the system as an arithmetical trick devised to reduce his piece-rates in proportion to his output. It infringes indeed the fundamental principle which we mentioned in our opening sentence, namely, that payment should be proportional to the value of the work done. Moreover, the automatic limitation of earnings under the system has a bad influence upon the efficiency of the management, for standard time rates can be set almost without reference to the time which the job should really occupy.

We have pointed out the difficulties which beset every system of payment by results yet devised, not for the sake of dissuading employers or workmen from adopting any particular system, but rather to emphasise the care necessary to ensure that the system chosen shall be workable under the conditions to which it is to be applied. The general principle of payment by results is so essentially sound, and when judiciously applied and honestly acted upon, it has proved so extraordinarily valuable in promoting efficiency, that there is a danger of regarding it as a panacea for nearly all workshop ills. The productiveness or otherwise of a workshop depends much more than is often realised upon matters over which the men have no control. The steady supply of material for every operation, the adequacy of tools and gauges, the arrangement of machines and other factors such as illumination, warmth, cleanliness anc space have all an enormous influence upon output, and these are matters for the management. To graft any system of payment by results upon an organisation in which production is unduly low on account of managerial defects, is to run the risk of stabilising inefficient conditions and of perpetuating high unit costs on account of the difficulty of altering rates when once set. This, we take it, is the main contention of Mr. J. F. Powell, in his paper on "The Future of Payment by Results," read on Tuesday last before the Institute of Industrial Administration. The author does not, as might be expected from the title of his paper, express any opinion as to which system is likely to survive, nor does he indicate his views as to how far payment by results can be advantageously applied to the engineering or any other industry generally.

We agree most cordially with Mr. Powell that if any system of payment by results is to be successful the rates must be based upon accurate data as to what output men can reasonably attain under efficient conditions of working, that these conditions must be maintained, and that the whole system must be honestly and sensibly carried out. No one indeed would dispute these statements, but they do not carry us much further. The fundamental question as to what is the best method of payment by results is left unanswered. We are inclined to believe that a straight piecework system commends itself most to both employers and workmen on account of its simplicity. With his day wage guaranteed, as it now always is, the workman is protected against failure to earn the standard rate, and if he feels confidence that his piece-rate will not be cut he has every inducement to exert his powers, to the benefit both of himself and of his firm. The possibilities of errors of judgment in rate-fixing are so great that an absolute guarantee that rates once fixed shall never be lowered can hardly be given, and, needless to say, it is the cutting of rates which has been the curse of the piecework system. The best way out of the difficulty appears to be to guarantee that a rate once set shall not be lowered on any pretence whatever for a period of, say, two years, when further negotiations may take place if necessary. This is long enough to induce a workman to "make hay while the sun shines," and should certain rates prove unduly high, it is better for the firm to pay them for a limited and definite period than to destroy the confidence of the men by altering them as soon as large earnings are made. It also lessens the temptation of the less reputable employers to introduce some trivial change in manufacture as an excuse for lowering piece prices, and thus does away with another source of irritation. Whatever method is employed, however, its success will depend less upon its details than upon the fairness and commonsense with which its principles are administered and the spirit in which its inevitable difficulties are met when they arise.

THE RAILLESS TROLLEY 'BUS.

IT is a good many years now since the railless or trackless trolley omnibus appeared to claim attention, and in the interval it must be admitted that its progress has been surprisingly slow. It is true that the war has intervened and possibly retarded development, though it did much on the other hand to accelerate that of its chief rival, the motor omnibus. In fact, while the latter advanced by such strides that this class of vehicle has become practically essential to our existence, the railless 'bus may be said to be only now reviving from a fit of suspended animation, and, if it is ever seriously going to take its place in our transport system, will have to work hard to improve its footing in order to make good before still more advanced means of locomotion become general.

The great hopes that have always been entertained of this system, which so far have failed to mature, have been stated before the engineering profession on numerous occasions in the past fifteen years. Even allowing for the hiatus caused by the war, the length of time which the system has been in actual use has been sufficient to produce a good deal of accurate data, and it is, we think, to be regretted that such data are not to be found in the paper read by Mr. C. W. J. Taffs before the Institution of Automobile Engineers on Wednesday last. Mr. Taffs admits that these are now available, and in our opinion he would have been more fortunate if his decision had been to keep to them, instead of, by preference, to generalities. The time is now passed for the latter in this particular connection, and we think most engineers would have preferred argument based on specific experience to the case as put forward in the paper under consideration. The average engineer is inclined to be impatient of the hypothetical case, unless the excuse can be made of extreme novelty. Where this is lacking, as in this instance, it is better, we believe, to refer to actual figures, explaining if need be any that may attract notice by being unduly high or low, rather than to adopt general figures which many are sure to cavil at as incompatible with their own experience. To that part of the paper, therefore, dealing with finance, we are afraid only a moderate value will be attached, though we are ready to admit that the case is very prettily worked out to show the advantage claimed for the railless 'bus over both the motor omnibus and the tram car. The latter, except for very heavy traffic, Mr. Taffs considers out of the question altogether.

The railless 'bus, according to Mr. Taffs' argument is superior to its rival of the internal-combustion motor, mainly through reduced depreciation in the rolling-stock of the service. This gives it an advantage both as regards standing charges and maintenance. The electric motor has, indeed, shown itself in recent years capable of such development in the direction of robust construction that it is now accepted as reliable in very severe service. It may be taken, therefore, that the electrical equipment of the vehicle is not responsible for the lack of headway made by the system, and we are quite prepared to join with Mr. Taffs in his appreciation of the electrically-propelled vehicle. But here, again, Mr. Taffs does not present a very convincing case. He presents arguments in favour of the series-parallel arrangement of motors and speed regulation by shunting the fields, but on the actual cost of running there is regrettably little said. This is even more pronouncedly the case as regards maintenance. We venture to think that at this time it would be more convincing to advance definite data on these points, for these are what engineers have to contend with, and only by the dissemination of such facts will progress be made.

The great handicap under which the system appears to lie is, we believe, its dependence upon permanent construction along its route. While the capital expenditure involved in this is not actually so very heavy, it has the great disadvantage of definitely reducing the flexibility of the service compared with that obtainable from the motor omnibus. We do not now refer to flexibility in traffic, in which, as a matter of fact, a well-designed trolley 'bus is not after all at any very great disadvantage; but we refer to choice of route. Practically, like the tramway, once a route has been adopted the trolley 'bus is committed to it for all time unless the loss on the erection of standards and conductors is to be written off. The motor 'bus, on the other hand, is absolutely free, and if a route is found to be capable of being better selected, or a length is up for repairs, the motor 'bus can be immediately diverted without any detriment to the service. In fact, the maintenance of the service in spite of such happenings is a strong recommendation in the eyes of the public.

The tramway has now become established in most towns of any size, though none too often a paying concern. In numerous cases routes which were expected to yield a good traffic have been laid down, but such traffic has never materialised. In some instances these routes have been abandoned; in others they are run at a loss. It is hardly surprising, with this experience, that the tendency should be in favour of the most flexible service possible, and that preference should be given to one which enables a good deal of what we may describe as "exploring," (not necessarily only of "avenues") before permanently committing an undertaking to irredeemable expenditure on permanent structures. The hypothetical case taken by Mr. Taffs of a new housing colony requiring definite connection with an industrial centre some distance off, is only typical of one of a multitude of problems confronting the traffic official. We believe that any one responsible to a board would much prefer if the question arose through previous misjudgment, as has not infrequently happened, to have to recommend the diversion of a motor 'bus to another route, to having to state the case for dismantling some miles of trolley line and re-erecting it elsewhere in the hope of improving the financial position of the undertaking.

It may be noted that the electric battery vehicle is, along its route, as flexible as the motor 'bus, and it is possible that, if ample charging facilities can be arranged, this vehicle may in time take a more prominent place in passenger service. It combines many of the advantages of the motor

'bus and the electrically-propelled vehicle, without the disadvantages of the trolley line, and it makes advantageous use of a supply which, as Mr. Taffs points out, is already in many cases in existence. At present, however, it is suitable for service of a restricted nature only, but the future may see this type develop in directions which would render it more generally adaptable.

COAL MINE HAULAGE.

THE primitive method of transporting material from the underground workings of a mine was for men to carry it in trays or other types of containers. This simple way of working has been retained until now in places where the material conditions are such that it is economically suitable. Wooden sleds or baskets fitted with runners and drawn by boys were made in the next stage in the evolution of modern practice. Later still, wheeled trucks, called tubs in England and cars in America, were introduced and made the transport of heavier loads a possibility. The process of pushing these tubs we term "putting," but in America it is known as "tramming." Cast-iron plates were used as a track from 1767, but were later superseded by wrought iron or steel rails. The American practice is to use trucks of much larger dimensions than those common in this country, and to this fact some authorities attribute a part of the increased output per man which is obtained there, but undoubtedly other factors have a large effect. Shetland ponies were introduced into British mines in 1843, following the enactment of a law prohibiting the employment of women, or of children under 10 years of age in the mines. In mines where the seams are thick, horses are employed and in Britain have remained the favourite animals for haulage, but mules are preferred to them in the United States generally, while, for thirty years, dogs have been trained to this work in some of the small Illinois pits.

A report issued recently as a University of Illinois Bulletin on "A Study of Coal Mine Haulage in Illinois," by H. H. Stoek, J. R. Fleming and A. J. Hoskin, gives much general information on this subject, as well as details about the methods in use in Illinois. This publication is the result of co-operative working between the Engineering Experimental Station of the University, the Illinois State Geological Survey and the United States Bureau of Mines. From it very valuable information may be obtained on methods of operation, the plant necessary and also on the costs, not only overall, but also for the various different sections of the work.

The principal forms of mechanical haulage in use are rope and locomotive driving. Rope haulage may be divided into four systems as follow: engine planes, gravity planes, endless ropes and main and tail rope working. An engine plane is one in which the load is taken up an inclined run with the empty truck balancing a part of the load on the heavy side of the system. Occasionally there is no balancing action and the unloaded tubs when going back are allowed to pull the rope down again. George Stephenson introduced the first system of mechanical haulage when he overhauled the installation at the Killingworth collieries about 1812 or 1813. Light round iron wire ropes were produced in 1841 and their suitability for mine work led to a great increase in the use of rope haulage. The gravity plane system is used when the coal must be taken to a lower level before being raised to the surface. In this case when the loaded trucks are descending their fall is used to pull up the empty ones on the adjacent lines. The endless rope system works at a rate of two to four miles per hour and the tubs are provided with grips or clamps, which may be easily fastened to or disengaged from the ropes. In the main and tail rope arrangement, the loaded trucks are drawn up by the main rope and drag a tail rope behind them. At the destination the ropes are uncoupled from the cars and the tail rope is fastened to the front and the main rope to the rear of a group of empty cars. These operations are performed in turn and the rate of rope movement is about 6 to 10 m.p.h.

Locomotive haulage which nowadays makes use of steam, compressed air, petroleum or electricity, was introduced into America about half a century ago. When smoke is produced, this system is restricted in use to the return airways. While much used in the anthracite mines of Pennsylvania, and for many years in the Pocahontas region of West Virginia, it has not found favour in Illinois. The compressed air locomotive was introduced to get over the disadvantages caused by the production of smoke and for the elimination of fire risks in gassy mines due to electrical faults. Large tanks containing air at a pressure of 600 to 1,000 pounds per square inch are carried on the locomotive and the supply is taken from them through a reducing valve to the engines, which it enters at 150 pounds per square inch pressure. In 1921, there were about 150 mines in Western Pennsylvania and West Virginia in which compressed air locomotives were used, but there were none in service in the coalfields of the Mississippi Valley. The radius of operation of this system is limited by the air storage capacity.

A locomotive of the type carrying its own source of power, such as petroleum, has great advantages and where conditions made their use possible, internal-combustion engines found favour before even the motor car had advanced beyond the experimental stage. The storage battery type of electric locomotives are, however, replacing them to a very great extent. An investigation conducted by the Bureau of Mines in 1914 led to the decision that the ventilation currents must be increased in proportions depending upon the sizes of and number of engines in use, in order to keep down the percentage of obnoxious gases in the total air flow.

The German firm of Siemens and Halske were the first to introduce electric locomotives where the supply is obtained from generators in a power station and showed their proposals in an exhibit at the Berlin Trade Exhibition in 1879. The actual use of the system followed shortly afterwards and the next ten years saw its application in American mines. To obtain the full advantage from the use of electric locomotives the extension of their service to the work of gathering trucks from the workings and hauling them to the main roads is effected by the use of a long cable connected to the trolley wires. In this way, the locomotive could travel close to the workings and into places where it was undesirable to fit trolley extensions. Rack-rail locomotives have been introduced in some cases for electric haulage on steep gradients. The early development of the storage battery locomotive was due to British and German engineers, the Americans being slow to take up the subject. For the varied purposes to which all electric locomotives are put, they must be able to withstand very heavy overloads, say of 300 or 400 per cent., for short periods. The use of forced ventilation in connection with the motors in such plant is almost essential. The introduction of commutation poles to the motors to prevent sparking and the thorough enclosing of all the electrical parts of the outfit has reduced the danger of fire and explosion, and also increased the life of the machines. The power of the main haulage locomotives is usually about 12 h.p. per ton of locomotive weight for machines above eight tons rating, but the application of forced ventilation made it possible to meet much more severe conditions demanding greater power. The speed of running is about 6 m.p.h. Progress in design has been made by the application of ball bearings to the motors, and the use in the general construction of materials with high stress-resisting properties which have been produced as the result of recent metallurgical research. In the early locomotives the axles were weak, the journal boxes were too short for the loads, the springs were not sufficiently flexible to meet the conditions of the mine truck, and the brake springs were quite unsuitable for the onerous conditions. Changes in details were made continuously until a serviceable and reliable machine was produced.

In America efforts have been made to standardise practice in mine haulage through a committee of the American Mining Congress. In Illinois, most of the large mines have seams of over 5 ft. thickness and thus permit the use of cars of larger capacity than is common elsewhere in the United States. The largest trucks in use hold about 5 tons and the average size is of about 3 tons capacity. In this area the floors being of fire clay afford a good road bed. In recent installations rails of 45 to 60 lbs. are used in the main roads and 25 to 35 lb. sizes elsewhere, the gauge being usually 3 ft. 6 in. The change in conditions of working is seen when it is stated that in 1899, 87·1 per cent. of the coal tonnage in Illinois was handled by animal haulage and a very small percentages by locomotives, ropes and tramming, whereas in 1921, both the rope and tramming systems were obsolete and 91·2 per cent. of the total tonnage was drawn by locomotives and the remainder by animals.

There are many matters for consideration in the lay-out of the shaft bottom. The track must be arranged so that the locomotive can deliver a number of loaded trucks and take away empty ones without delay so as to prevent the interference of one locomotive with another. Storage space for the tubs must be available in the event of stoppage of the regular system of working through any cause. The gradients at this point must be suitable for easy working whatever system of handling the loads is adopted. Careful consideration must be given to the arrangements for running the trucks on to the cages. There must be ample space provided for the gathering of the men at the bottom of the shaft before being taken up to the surface, and also for the handling of equipment and supplies.

When the control of the truck passes from the locomotive, its movement is regulated by the use of sprags on a grade of from 1·5 per cent. to 2 per cent., increased to 3 per cent. for a distance of about two truck lengths from the cage, so that it has sufficient impetus to bump the empty one off the cage. When this arrangement is impossible of achievement, or for some reason is undesirable, a small locomotive on a third or centre track may be used to push the tubs forward. Lifts are sometimes used to raise the empty tubs after they have left the cage, to the top part of an inclined track to cause them to run by gravity to that part of the track used as a store for empty tubs. A central repair shop for locomotives is commonly provided at the shaft bottom, but broken tubs are usually raised to the surface for repairs. Beside the repair shop, a supply room, in charge of a storekeeper, is useful in aiding the keeping of records of the repairs on each machine and locomotive. Generally a large amount of support is needed for the roof and side walls at the shaft bottom, and concrete arches or steel beams, with wood or a concrete filling between them, have been erected for both roof and side walls.

A committee of the American Mining Congress for the Standardisation of Underground Transportation Equipment, co-operating with the Industrial Car Manufacturers' Institute, recommended the use of a gauge of 3 ft. 6 in. for all new developments, a wheel base of the same dimension, and a length of the tub or car body of three times that value. Another important decision was that standardised automatic couplings, comparable to those of railways on the surface, should be fitted to the trucks at heights of 9 in., 10 in. or 11 in. above the top of the rail, for trucks with wheel diameters of 14 in., 16 in. and 18 in. respectively.

It is difficult to make comparisons in the items of the costs of haulage because of the lack of uniformity in accounting, and a Committee on a Standard System of Accounting and Analysis of Cost Production of the National Coal Association has prepared a report on the matter and recommended a uniform scheme which it is intended to use in future. The total cost of haulage, excluding the actual raising to the surface, taking the average found in the operations of 12 Illinois mines, works out at 45.10 cents per ton, of which the labour charges account for 34.66 cents per ton. The results in the individual mines vary from the average to the extent of 50 per cent. high or low according to the magnitude of the output. The figures given in the tables in the University of Illinois Bulletin bring out the saving effected in the cost of operating if large trucks are used. When tubs are taken to the working face by locomotives, they should be of the greatest capacity which the conditions permit, as the time occupied in taking a single car to the face is no greater for a large than for a small tub, and the longer the train the longer it takes to load. An item

of importance in this question is the reduction in the cost of handling a ton in big tubs rather than small ones at the shaft bottom, which, in the case of Illinois mines, is the difference between 1.31 and 1.51 cents per ton.

THE SOCIETY OF NAVAL ARCHITECTS OF JAPAN.

THE twenty-fifth anniversary meeting of the Society of Naval Architects of Japan was held on Saturday, October 28, at the Imperial Hotel, Tokyo, and on the following day at the Tokyo Industry Club.

Constructor-Rear-Admiral M. Kondo, in his presidential address, referred to the growth of the society in the quarter-century of its existence and gave the present membership as 1,676. The work done by the society on the standardisation of cargo ships, both in regard to dimensions and materials, which was the subject of an investigation by a committee, was dealt with by the President, who also described the steps in the progress of the shipbuilding industry in Japan.

A letter of congratulation from the president, council and members of the Institution of Naval Architects, the senior society of its character, was read to the meeting. Other messages from Japanese and other societies having been read, Dr. Sperry conveyed the greetings of the Engineering Foundation, a body composed of delegates from the various American engineering and shipbuilding institutions, and presented an address of congratulations from the American Society of Naval Architects and Marine Engineers.

Captain Robert Stocker, Assistant Chief of the Bureau of Construction and Repair of the United States Navy, read a paper on "The Effect on Design of the Recent Naval Treaty," and basing his arguments on those clauses, which he quoted, that affect the work of the designers of naval craft, he contended that the work of the naval constructors had grown in importance. The navies are now limited by the agreements made between the representatives of the maritime nations at the conference on Limitation of Armaments, held at Washington. Abbreviated, Captain Stocker's views are as follows:

The effects of the provisions of the Treaty upon the design of capital ships to replace those reaching the scrapping age are of great importance, as these vessels are, in number and size, taken as the index of the dimensions of the whole navy. Nothing is said in the Treaty about the number of such ships which may be possessed by any power, but the total tonnage of all, the maximum displacement of each, and the limits of size of guns are all exactly defined. The maximum displacement of 35,000 tons includes a number of items which may be classed as consumables, such as ammunition, stores, provisions and drinking water. The magnitude of some of these items is affected by the radius of action, but the variation in different navies will not actually be great. The dimensions of docks have generally limited the length and beam of ships, the depths of channels have limited their draught, and the money available, their cost. Such limits may be very elastic, for their change is not impossible. The limits imposed through the Treaty are, however, definite, but by careful design the weight of structural steel and steel castings may be reduced to allow the use of machinery of greater weight and power. The additional protection needed because of the use of aircraft, and the necessity for anti-aircraft guns, reduce the magnitude of this possibility. The old practice of adding more and more weight without ever removing any, will now have to be abandoned. Whatever new features may be introduced must always be considered in reference to what can be omitted to permit of their inclusion. The stresses of the sea and of gun-fire must be met in such a way that there is no redundant material, and the engines must be designed to give the maximum horse-power per ton weight or there will be a risk of the vessels being outclassed by those of other navies.

Aircraft carriers have similar restrictions to battleships, namely, limitation of total tonnage and individual displacement. In addition, they must be designed for the specific and sole purpose of carrying aircraft. For smaller craft there is no limit to the total tonnage, but the individual displacement must not exceed 10,000 tons, and the calibre of the guns must not be over 8 in. The time has now been reached when a full, thorough and scientific study of the features of naval vessels is essential, and when the intelligent exercise of the designer's profession is paramount.

An interesting paper on "Partial Discussion of the Vibrations of Marine Geared Turbines" was contributed by Mr. J. H. Macalpine, and appears in this issue, on page 59.

"The Strength of Ships" was dealt with by Dr. A. M. Robb, of Glasgow. This paper was accompanied by an introduction from Sir John Harvard Biles, who had asked Dr. Robb to obtain notes for the treatment of the subject relating to its development during the last thirty years. The paper represented the method of dealing with the subject adopted by the Glasgow school during the period Sir John Biles was Professor of Naval Architecture in the university. We summarise the paper:

After considering the progress so far made in the solution of design questions, the author referred to the inadequacy of existing knowledge. Superposed on its function as the shell of the box-girder and its purpose as an element of the frame-girder, the shell plating is called upon to resist water pressure. The combination of the stresses due to the bending moment on the structure as a whole and those due to water pressure is, in general, comparatively simple, since the stresses are in the same direction and the process used is simple addition. But the further addition of stresses at right angles introduces a complication. It would be interesting to know whether the combined effect of tension and compression in two directions at right angles to each other is to reduce the ultimate strength. The consideration of a ship as a simple box-girder needs some modification as there must always be large openings in the top "flange" for access to the interior, and there may be superstructures on the girder which are necessary for its function as a ship. So far, the investigation of stress variations due to these "discontinuities" have only been dealt with in reference to specimens of uniform thickness throughout. The experiments, also, have only been made on specimens in which the lines of principal stress are axial in the regions remote from the openings. Such conditions do not exist in the deck of a ship. The early investigation by Dr. Purvis into the effect of adding material above the top member of the box-girder showed that such an action does not necessarily strengthen it, but may actually render the added material liable to stresses considerably greater than those in the original girder. The general theory of the strength of ships has need of amplification in many respects. The question of transverse strength needs consideration, as well as the distribution of stress in a complex girder.

The paper presented by Messrs. H. L. Guy and P. L. Jones on the "Metropolitan-Vickers Rateau Marine Turbine" we hope to reprint in a future issue.

Mr. N. W. Akimoff, of Philadelphia, read a paper on "Vibrations in Ships," in which he stated that it was not an uncommon occurrence to have to alter the speed of a vessel to other than that it was designed for, because of excessive vibrations in some particular part. In war vessels, troubles had been caused by such actions upon the delicate instruments located in the fighting tops and on the platforms of the masts. Long-range firing was especially affected by these conditions. Great difficulties had been experienced in the running of some types of submarines at their designed speeds from the same cause. The author described instruments that he devised to study these vibration actions with a view to eliminating them completely, and dealt with their use in the study of static and dynamic balancing.

"The Applications of Electricity on Ships" was the subject of a paper by G. Yamataka.

Dr. Elmer A. Sperry gave a paper on "The Gyro Ship Stabilizer," in which he provided a résumé of the main attempts made to overcome rolling actions and to improve the stability of a ship, and described, in detail, the well-known system he invented. Dr. S. Motora contributed a paper on his scheme of ship stabilization.

"The Use of Oil as Fuel" was the title of a paper by Professor Ernest H. Peabody, of New York, in the early part of which he made a comparison of mechanical and steam atomizers and described various types, in particular, the Peabody-Fisher (see ENGINEERING, Vol. cxi, p. 225). After describing various installations in naval, mercantile marine and land practice, the author referred to the restriction of efficient working by incompetent and careless operators. The principal trouble was due to the fact that an oil-fire would burn with a brisk white flame while there was a greater excess of air than was actually required. Vigilance was necessary to keep down this value, and designers were trying to introduce improvements which they hoped might make it difficult for careless operators to spoil the performance. A centralised control in the hands of one intelligent worker might be effective in preventing a considerable amount of waste.

Other papers read at the anniversary meeting were given by Constructor-Vice-Admiral K. Yamamoto, on "The Development of the War Ships of the Imperial Japanese Navy," by Dr. M. Tsutsumi, dealing with the progress in merchant shipbuilding in the last twenty-five years, and by Professor Terano, on the progress in naval architectural science in Japan during the same period.

NOTES.

FOREMEN'S MUTUAL BENEFIT SOCIETY.

AN institution which serves the combined purposes of a technical society, a friendly society and an association in which the foremen in our engineering, shipbuilding and allied industrial works can join together for the representation of the views of this important section of employees, demands consideration. The number of the members has now reached 13,500, and the accumulated funds amount to 800,000*l*. One unique feature of this institution is that the employers pay to the society contributions equal in amount to those paid by their foremen who are members. Out of the funds so accumulated, sickness, unemployment, life insurance and old-age pensions are provided. In this way a sum of no less than 350,000*l*. has been paid out since the scheme was started in 1899. With a membership having an exceptionally low sickness and mortality experience, the ratios of which are only 60 per cent. and 50 per cent. of the expected values respectively, the society is one of great interest to all concerned with insurance matters. Social activities are not neglected by the members, and the annual dinner of the London District attracted a company of 500 ladies and gentlemen to the Holborn Restaurant, Kingsway, on Saturday, January 6, over which Sir Allan Smith, M.P., chairman of the Engineering and National Employers' Federation, presided. Amongst those present were many leading engineering employers in the London area and their associations, including Messrs. S. D. Begbie, T. Wheatley, H. J. Ward, James Brown and Hugh Latter, as well as prominent officials of the society, including Mr. Thomas Biggart and Mr. Edward Wolledge. The speeches of Mr. Albert G. O'Neill, a member of the society, who proposed the toast of the "Engineering and National Employers' Federation," and of the chairman, who replied, did much to show the very amicable relationships between the foremen and their employers and their determination to work together for the improvement of production.

THE BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION.

That much research work of a directly practical nature is still waiting to be done in the electrical field is well illustrated by the Second Annual Report of the British Electrical and Allied Industries Research Association, which appeared a few days ago. This body is naturally not directly concerned with pure research, which offers an apparently limitless field, but for the present, at any rate, it is evidently confronted with more direct practical research problems than it can well deal with. The very strong Council which directs the activities of the association will always be far from overlooking any development of pure research which appears likely to help forward the objects for which the association exists. The various researches which

are at present being prosecuted have been dealt with on various occasions in our columns and there is no need to refer to them in any detail now. They cover work on fibrous insulating materials, synthetic resins, composite insulating materials, mica, insulation oils, overhead lines, control apparatus, corrosion, turbine nozzles and blades, &c. The corrosion work is being carried out in co-operation with the Institute of Metals and that on turbine nozzles with the Institution of Mechanical Engineers. The actual practical work involved in the various researches with which the Association is concerned is being done by various manufacturers, by the National Physical Laboratory and in various technical colleges and universities. As pointed out in the report, a gratifying feature of the year's work has been the increasing extent to which large manufacturers and specialists have extended their co-operation to the Association. Some doubts were originally expressed about the value of the Association to the large manufacturer who was supposed capable of carrying out his own research work. It was suggested that the small manufacturer would gain at the expense of the large. These ideas appear to have been quite fallacious, and the larger concerns are not only cordially supporting the Association, but appear to be profiting from its activities equally with the smaller undertaking.

The Trade Facilities Act.

In this country our great railway systems were built up without Government assistance, and, indeed, in the face of a somewhat strenuous and costly Parliamentary opposition. In America, too, the major part of the network has been constructed by unaided private capital, although national grants were quite properly made to ensure the early construction of certain of the transcontinental lines, Elsewhere capital was not so readily forthcoming, and in France, in particular, it was found necessary to guarantee interest upon the subscribed capital. Heavy taxation, combined with high labour costs, have made necessary, in the present crisis, a departure from old methods and has compelled us to follow the French precedent, by passing Trade Facilities Acts. Of these, the first became law in November, 1921, and under it guarantees were given in connection with capital amounting to 22,243,645*l.* Under a new Act the total sum that may be guaranteed is 50,000,000*l.* The "awards" are controlled by an advisory committee, who so far have sanctioned in all 34 guarantees, the amounts ranging from 4,500*l.* to 6,458,000*l.* The total of fifty millions appears very small in comparison with the cost of the doles to the unemployed, and this alternative method of easing the situation has the advantage that no money has to be found in the first instance out of the taxes, and possibly the guarantees may never involve any substantial charge on the Treasury. The conditions explained in a Government questionaire just issued require that the capital shall be for work of real utility, and none of it can be expended in writing off deficits or the like. The whole amount, moreover, must be expended in England, a requirement which will facilitate our future competition in foreign markets, by providing our engineers with much valuable experience. Most of the capital thus to be raised will be expended in labour, and as a remedy for unemployment the method is obviously far superior to doles. It has the advantage over many other suggestions in that only schemes promising a future profit are likely to be promoted by those seeking a guarantee. This is not the case with many proposals for public works which have been advocated of recent years. During the later years of the war the columns of the popular press, for example, teemed with schemes for beautifying London, though the exceptional few who had studied history were well aware that indulgence in such "luxuries" would be out of place for many years following the re-establishment of peace.

The Diamond Jubilee of the Metropolitan Railway.

In these days of short memories it is well now and then to spend a moment or two in reflection, carrying the mind back to some distance of time before the war. We hear so much nowadays of post-war conditions, while reports always allude to 1913-14 as the chief year to consider in connection with pre-war conditions, that we are apt to limit ourselves altogether too much to the immediate past. Going a little further back many of course will remember the change which has gradually come over London by dint of improvements in transport. It is impossible now to realise what London would be like without its Metropolitan and District and Tube Railways. In fact, London as it is to-day would simply not exist. The younger generation find it hard to imagine what the underground systems must have been like before electricity came upon the scenes, but there are yet plenty with us who can remember the inauguration of underground transport in the metropolis. On Wednesday last the Metropolitan Railway celebrated its Diamond Jubilee, and though, of course, the founders of this useful pioneering undertaking have ceased to trouble themselves about its affairs, there are many within whose recollection the opening of the new railway must have left distinct impressions. For the date when it was embarked upon the Metropolitan Railway was a very bold financial and engineering scheme. With its main idea one of linking the great terminal stations of Paddington, Euston, King's Cross and St. Pancras with the City, its prospects must have appeared extremely attractive. From the engineering point of view the work was unprecedentedly heavy, and the effect of steam working on long covered routes was only a matter of conjecture. However, the railway was ultimately put through with only one really serious set-back—the flooding of the whole tunnel from Farringdon-street to King's Cross to a depth of 10 ft., by the bursting of the Fleet diversion sewer. It will come as a surprise to many that the Metropolitan was first operated as a broad-gauge line by the Great Western. For some time subsequently the broad and narrow gauge existed side by side, on the three-rail system. The progressive policy of the railway has always been well maintained, in spite of the fact that at the end of the last century it was the habit of people to censure it for the discomfort sometimes experienced on certain stretches of the line. It was one of the early lines in London to adopt electric traction, and in later years has kept moving ahead rapidly so that its reputation stands as high as that of any other. In fact, the service given in many respects is quite unapproached by other suburban systems. We venture to extend to the company our hearty congratulations on its anniversary, and our hope that it may long continue its present successful services to the public.

The Shipbuilding Industry.

For some time recently records for the shipbuilding industry continually impressed upon us the fact that practically everything was at a standstill—that work on much tonnage had been suspended, that launches were emptying the slips and no new ships were being laid down. We are glad to think that we seem at last to have got away definitely from this state of affairs, and though it is too early yet to assert that things are going well, it seems pretty near the mark to say they are looking up. The latest returns issued by Lloyd's Register show that the new tonnage commenced in the last quarter of 1922 reached an amount which was within 30,000 tons of the shipping launched, and it is to be hoped that continued expansion will soon result not only in the two being equal, but in the new tonnage exceeding that launched to such an extent that our yards may once more be replenished with work. The total tonnage commenced in the world in the last quarter of 1922, is put at 344,680. Of this amount 231,187 tons were laid down in Great Britain and Ireland, the next most important country being the United States with only 45,050 tons. At the close of the year there were 315 merchant vessels on the stocks in our yards, aggregating 1,468,599 tons, and while a number of them were small, a good proportion are of what a few years ago would have been a good size, between 5,000 tons and 10,000 tons, while no less than 11 are between 15,000 tons and 20,000 tons, and six between the latter figure and 30,000 tons. This construction, however, includes 348,000 tons on which work has been suspended. Deducting this, the tonnage building is much below half of what it was at the end of 1921, so that there is a long way to go before we can consider conditions to be even satisfactory. The total under construction in the world is put at 2,954,318 tons, of which 288,057 tons represent motor vessels. Great Britain, it may be noted, is constructing in this class 26 out of the 107 vessels building, but the tonnage of those in our yards aggregates 125,350, which is more than half the total, so that on the average British motor vessels are larger than those built abroad. This may be taken to be an excellent testimonial to the reliability of the British motor ship. One motor vessel now building here is recorded in the class of 15,000 tons to 20,000 tons, while the majority are over 5,000 tons. In the matter of tankers all countries show together construction amounting to about 300,000 tons, of which Great Britain and Ireland are responsible for 204,704 tons in 31 vessels. The average size in this case works out at rather below the mean of two vessels building at the present time in Germany. As regards the various centres, Barrow, Maryport and Workington, Greenock, Hull, Leith and Middlesbrough (including Stockton and Whitby) alone show improvement on the figures for the quarter closing at the end of September. In no case is the improvement very material except as regards the first group of three ports which show an increase of nearly 20,000 tons, and the last-named group, which has improved by about 26,000 tons.

Physico-Chemical Significance of Flashpoint Temperatures.

A year ago Dr. W. R. Ormandy communicated to the Institution of Petroleum Technologists the results of experiments on flashpoints, from which he concluded that the ratio R of flashpoint to boiling point had, for a large variety of organic compounds, benzene and homologues, kerosenes, alcohols, &c., the fairly constant value $R = 0{\cdot}736$. These researches were noticed on page 80 of our issue of January 20, 1922. Last Tuesday Dr. Ormandy and Mr. E. C. Craven presented to the same body an account of their further investigations. This work concerns mainly four problems: determinations of vapour tensions, flashpoints at reduced and increased pressures, flashpoints in mixed gases, and flashpoints of preheated vapour-air mixtures. Vapour tensions may not appear to be of much consequence to the engineer; but if we know the vapour tension we can at once deduce the amount of vapour present—provided we deal with pure vapour-air mixtures, at any rate. The engineer has most to do with mixed vapours, however, and Dr. Ormandy found another unexpected source of trouble in these determinations. All these vapours contain dissolved gases, in very small proportions, it is true, but enough to give too high vapour-tension figures, especially when the determinations are made at low temperatures (below freezing point), and the gases are very difficult to remove. What the dissolved gases are is not clear yet. But they again come in strongly in the tests at reduced gas pressures, down to 200 mm. of mercury; at still lower pressures the flashes become very weak. As the pressure diminishes, the flashpoint temperature goes down. The experiments at higher pressures, up to 7 atmospheres, were made in a steel cup, closed by a screwed-down top, which was made by Messrs. Ricardo; the cup can be heated or cooled. With increasing temperature the flashpoint temperature rises, in the case of "de-gassed" toluene, *e.g.*, from 10 deg. C. at 1 atmosphere to 37 deg. C. at 6 atmospheres. Most of the experiments have been made with heptane, toluene and ethyl alcohol, as typical substances. But a great many other compounds have been tested, and when the flashpoints are plotted against the logarithms of the pressures, straight lines, mostly of uniform slope, are obtained. The uniform slope, Mr. A. T. Tizard, of Oxford, remarked during the discussion, probably indicates equal latent heats, and the latent heat also effects other relations. When we mix alcohol vapour, *e.g.*, with gases, an excess of oxygen may have the same effect on the inflammability limit as an excess of nitrogen, both the gases acting practically as diluents; but the effect of various proportions of carbon dioxide may be quite different, the CO_2 curve crossing that of oxygen and nitrogen. Heat conduction, convection and radiations have

also to be considered, of course, and the phenomena are, in fact, so complex even in laboratory tests, that it would be unsafe to lay down any general rules without fully specifying the exact experimental conditions. The weight and volume of the sample, the nature, material and surface conditions of the vessel, the character of the ignition, the neighbourhood of masses of metal, temperature, turbulence, &c., all have strong influences. For internal-combustion engine experiments, Dr. Ormanby would like to rely entirely on ignition by compression, since the results of different methods of spark and of hot-wire ignition differ widely. There are peculiar time-lags in the ignition, moreover, and oil vapours pushed into a cylinder may require 700 deg. C. to ignite, while drops of the same oil would ignite when falling upon plates at only 200 deg. Dr. Ormandy and Mr. Craven admitted to be somewhat discouraged by the slow progress of their investigations.

NOTES ON NEW BOOKS.

The engineering draughtsman of to-day requires in his library something more than the mere collection of formulas in which his predecessor of a generation ago imposed so implicit a trust, without always be it said being justified by the results. This is particularly the case in departments of engineering in which practice has not yet become thoroughly standardised and where the exercise of judgment and a fair amount of theoretical knowledge is required in order to estimate the effect of alterations in a design or changes in conditions. This is still the case with the steam turbine, and those requiring an elementary treatise on this important subject will, we think, appreciate the volume recently published by Sir Isaac Pitman and Sons, Limited, under the title "*Steam Turbine Theory and Practice.*" The author is Mr. W. J. Kearton, Assoc.M.Inst.N.A., who is lecturer in engineering at the Liverpool University. Judging from internal evidence, Mr. Kearton has been personally engaged in the design of marine steam turbines and knows from actual experience the kind of information immediately useful. Some of his *obiter dicta* are perhaps open to criticism, but these for the most part are of minor importance. The author should certainly have pointed out to the elementary student that the sole merit of the steam tables, which he recommends for use, is their great convenience, but that the entries are inconsistent with each other. Moreover, the author himself is inconsistent in adopting the formula $p\,v^{1\cdot3}$ for the relation between pressure and temperature in the adiabatic expansion of superheated steam. To agree with the steam tables he recommends that the index should be 1·33. These, however, are minor blemishes, and the author explains very clearly the Mollier diagram, the proportioning of nozzles and the methods of determining the "diagram" efficiency of a turbine stage. One investigation should, however, have immediate correction by the issue of an erratum slip, viz., the attempt to determine by a geometrical construction the loss which may arise when the flow of steam from the guide blades strikes on the back of the moving blades. This section crystallises a very prevalent error and the construction is fundamentally unsound. Any loss thus occasioned is indirect, since the "back pressure" on the blade is necessarily balanced by an additional tangential momentum communicated to the steam, which is carried on to the next blade. It is quite probable that there is a net loss, but this must be due to secondary causes such as the production of additional turbulence in the flow.

Rapid progress within recent years in almost all the applications of internal-combustion prime movers calls for the repeated re-editing of text books devoted to this subject and the issue of fresh and up-to-date editions. The fourth edition of "*Internal Combustion Engine,*" by H. E. Wimperis, M.A. (Constable and Co., Limited; 12*s.* 6*d.* net), is a work now of some 300 odd pages of relatively small size, using commendably large type and with over 100 illustrations and tables; but even so, it cannot, of course, pretend in any way to deal exhaustively with this great and enlarging field. The book under review is divided into three main sections, each of about equal length. The first deals with thermodynamics, the second with gas engines and producers, and the third with petrol and oil engines. The volume is typical of many others, in that there is included the usual treatise on the thermodynamical theory of internal combustion. The repetition year by year in new editions and in new text books of this standard elementary scientific exposition should, we feel, be avoided, especially in a volume which is not and cannot within the scope of one work deal completely with the whole field. We commend this opinion to future writers on this subject. In this work, the section dealing with gas engines is the most complete. Oil engines are merely touched upon. A good index is provided at the end.

To the technical man an emulsion, for instance, of an oil in a well with water, is generally a nuisance. He is quite aware that, in the scientific sense, there are many practically and theoretically important emulsions, such as milk, rubber latex, soaps, &c.; but these substances he does not call emulsions. In his "*Theory of Emulsions and Emulsification*" (London: J. and A. Churchill, 7, Great Marlborough-street, W.; price 9*s.* 6*d.* net), Dr. William Clayton, F.I.C., of Liverpool, secretary to the British Association Committee on Colloid Chemistry, defines an emulsion simply as a system containing two liquid phases, one of which (the dispersed phase) is dispersed as globules in the other (the continuous phase or dispersing medium); the two liquids should be immiscible or nearly immiscible. The two constituents may change places, that is, water may be dispersed in oil, or oil in water. When we produce an emulsion, for instance, by shaking the two constituents together, the dispersed particles will tend to coalesce again. Stable emulsions are of very low concentration; the very fine oil globules in condenser water make up about 1 part in 10,000 of the whole mass. Such diluted emulsions are akin to colloidal suspensions. Emulsifiers render the emulsion more stable; the emulsifiers may be liquids (alkalis, gelatin, albuminoids) or also solids (clay, finely divided calcium carbonate, &c.). The theory of emulsions, to which the main part of this volume of 160 octavo pages is devoted, remains in a very controversial state, partly because the studies, though extensive, have not as yet gone far outside the domain of aqueous emulsions. Hence Dr. Clayton gives summaries of the views of different authorities rather than a concise general theory. There are even many puzzling things in the chapters on applied emulsification and de-emulsification, which take up nearly one-quarter of the volume. Thus it is not easy to understand why an emulsified oil which could not be broken up by some, usually successful, centrifugal process, should have separated into oil and water when in transit on an express train. Very instructive are the kinematograph records reproduced of the gradual coalescence of fine oil globules to big drops which W. G. and H. C. Eddy obtained by treating an oil emulsion with alternating currents of 11,000 volts in a steel tank on the Cottrell dehydration system. In other processes oil emulsions are clarified by means of direct current of low voltage, whilst the Davis-Perret de-oiling process for condenser water needs currents of 110 volts, but, in addition, iron electrodes, the oxidised flakes of which enter into the reactions.

Even experienced designers of steam engines, fittings and appliances will find much of value in the little handbook on steam vessels which has been prepared by the National Boiler and General Insurance Company, Limited, of Manchester, and is published from their offices at the National Buildings, St. Mary's Passage, at the price of 2*s.* Steam in quantity is not only used for power production, but for many processes in chemical works, breweries and paper factories. In smaller amounts it is used by bakers and confectioners, and also by clothing manufacturers, whilst some of our public institutions employ steam heat on a fairly large scale. The publication under review is more especially concerned with these subsidiary applications and deals clearly and adequately with the precautions necessary to secure safety of operation. Steam pipes and connections are first discussed, and there are some valuable observations on reducing valves. Accompanying the notes on steam vessels are some interesting illustrations of different types of corrosion, and attention is drawn to the liability of rag boilers to suffer from grooving in the neighbourhood of the trunnions. Later on, some useful hints are given on the design of covers for various types of steam vessel. There are other useful notes on the construction of jacketed evaporating pans, stills and steam-heated ironing machines.

To those who find it more and more difficult to keep, even in a moderate sense, in touch with the modern progress of physics, books like the "*Molecular Physics*" of Dr. J. A. Crowther, demonstrator in experimental physics at the Cavendish Laboratory and lecturer on radiology, Cambridge University, will be very welcome. The third edition of this work (London: J. and A. Churchill; price 7*s.* 6*d.* net), largely re-written, can treat almost as certainties some advances in modern thought which could not be regarded as more than probabilities in 1919. The engineer may be able to acquaint himself with the particulars of some research; but the general bearing of the experiments upon his previous conceptions may be confusing. The direction in which further advance seems likely to be made appears fairly clear by now; the uncomfortable feeling that some new line of investigation might sweep away many of the novel notions is gradually vanishing. We rather doubt, however, whether the title "*Molecular Physics*" will be retained in a future edition. The title Theoretical Physics would too much suggest pages of mathematical deductions, which Dr. Crowther spares the reader; the terms modern or new physics would be too indefinite and objectionable on general grounds. Yet to entitle a book "*Molecular Physics,*" in which most chapters deal with electrons and atoms, and in which the term molecular only enters into the heading of one chapter of 14 pages—there are 180 pages altogether in the 12mo volume—on the Molecular Theory of Matter, may look a little incongruous. Many of the phenomena discussed concern electric discharges through rarefied gases; the particles of the rare gases and of metallic vapours are supposed to be atoms, not molecules; in positive ray analysis we have to deal with molecules as well as with atoms, and on the whole we fancy now we know something about the structure of the atom, but we feel very dubious as regards the molecule. Dr. Crowther himself asks in his concluding paragraphs: Is the atom born to grow old, to decay and die? But there is, of course, a great deal to be said in favour of adhering to Molecular Physics, if simply on the argument that the greater comprises the less, and the book is certainly good.

An American work entitled "*Steam Engine Principles and Practice,*" and edited by Mr. Terrell Croft (Mcgraw-Hill Book Company, Inc., London and New York; 17*s.* 6*d.* net), departs from usual practice, in that no data relative to design are given, and that it deals principally with the horizontal type of steam engines still largely in vogue for many duties on shore. It presents in its 500 odd pages a very complete series of illustrations, totalling in number over 500, of almost every variable in horizontal steam engine practice as regards arrangement, main parts and details. In many cases these illustrations are rather on the small side, evidently on the assumption that it is better to have small scaled illustrations in such a number as fully to cover the whole field, rather than fewer reproductions to a more convenient size. One section of particular interest deals with indicator cards, and the faults which are revealed in this way have been very fully treated. The practice illustrated in this book is, of course, largely American.

In every mechanical engineer's drawing office there are certain details of machinery which enter so frequently into designs that their proportions should be decided upon once for all. By standardising their dimensions over a range of sizes not only is the work of the draughtsman lessened but manufacture is cheapened, and the products of the firm have a consistent appearance which is of commercial value. The Engineering Standards Committee has been devoting itself for years to the standardisation of articles and dimensions which have to be interchangeable between different manufacturers, but there is an enormous field for systematisation of design which lies quite outside the duties of this committee. The inclusion in many engineers' handbooks of tabulated dimensions of similar articles of different sizes is a recognition of this need, and in "*Mechanical Engineering Detail Tables,*" by John P. Ross (London: Sir Isaac Pitman and Sons, Limited, 1923; price 7*s.* 6*d.* net), we have over 100 different mechanical details illustrated and suitable dimensions given for all sizes in which they are likely to be made. On the whole the book is a good and useful one, particularly for small drawing offices, but many of the designs would deservedly come in for the severest criticism at the hands of a competent head-draughtsman. We find cast-iron shaft couplings, for example, embodying almost every error possible in design. Each half-coupling is shown secured to its shaft by two gib-headed keys, the shafts are swelled at the ends, the nuts and bolt heads are unprotected, there is no attempt to provide for registration of the flanges, and couplings for shafts, from 2½ in. to 4 in. diameter, are designed with five bolts. Even a first-year apprentice would not commit such an avalanche of blunders, and we would hardly imagine that the design could be produced at all outside the walls of a technical school. Another extraordinary design is that of a connecting-rod end of the strap, gib and cotter type. Although listed in sizes up to 10 in. diameter of brasses, there are no bolts through the strap, no set-screw or other device for holding the cotter, and the gib has four working faces in the strap, as the gib-heads themselves bear against projections. The strap is turned on the outside and has an extraordinary and utterly useless raised belt round the middle of it, just in advance of the cotter hole. We have never seen such a connecting-rod end in practice, and we certainly would not recommend anyone to make or use it.

The prevention of casualties in large industrial concerns is an ever-present problem, and safety devices, precautionary measures, and stringent regulations

EITHER-SIDE RAILWAY WAGON BRAKE.

CONSTRUCTED BY MESSRS. DICKSON AND MANN, LIMITED, ENGINEERS, ARMADALE, WEST LOTHIAN.

Fig. 1.

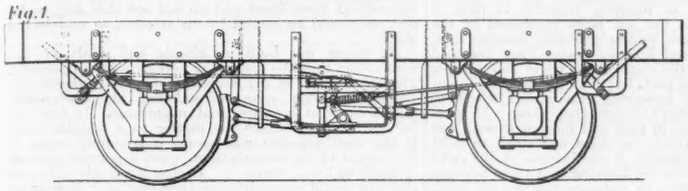


Fig. 2.

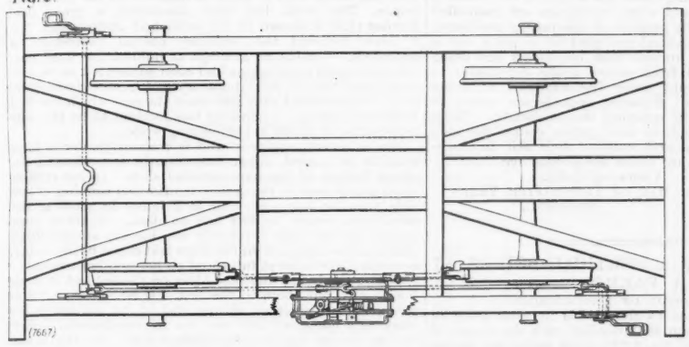


Fig. 3.

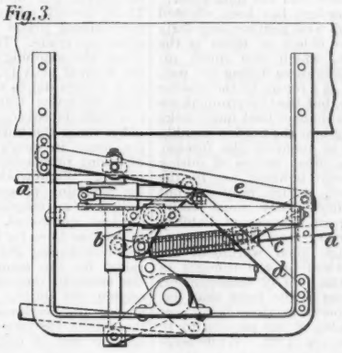


Fig. 4.

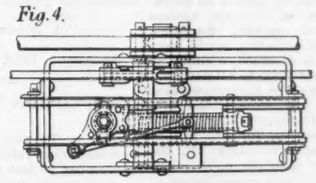


Fig. 5.

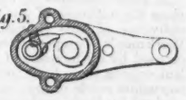
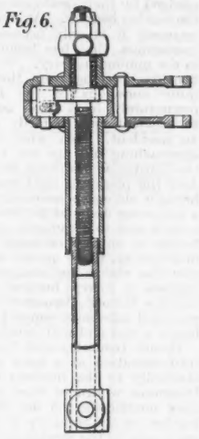


Fig. 6.



have been found to be increasingly necessary. In "*Causes and Prevention of Accidents in the Iron and Steel Industry*, 1910–1919," by L. W. Chaney, published by the United States Department of Labour, Washington, June, 1922 (Bulletin No. 298, price 60 cents), the whole question is treated in a thoroughly logical manner. The base taken in all statistics quoted is the number of "hours of exposure" or "man-hours." For example, a factory having an average number of employees of 1,000, and being in operation 2,750 hours during a year, would have 2,750,000 hours of exposure. Accident "frequency" rates which show the number of accidents per 1,000,000 hours of exposure are, rightly, not deemed sufficient, and accident "severity" rates, which show the number of days lost, through accident, per 1,000 hours of exposure, have been originated. Death or permanent total disablement are ingeniously expressed in terms of the severity rate. In all tables, charts, and graphs, of which there are a considerable number in the book, the two rates are given side by side. The letterpress is excellent and the author explains numerous safety devices which have proved highly useful in industrial plants; some 23 plates, from photographs taken under works' conditions, show these devices in actual use. Taking 1906 and 1913 as being average years it is encouraging to note that both frequency and severity rates have steadily fallen. There are various factors at work but, undoubtedly, the decline observed is chiefly due to organised effort at accident prevention.

EITHER-SIDE RAILWAY WAGON BRAKE.

THE problem of braking railway wagons from either side so as to render it unnecessary for shunters to cross from one side of the track to the other has produced several solutions, some of which have been applied to a considerable extent. An interesting device of this nature which has proved, we understand, entirely satisfactory during the past two years in which it has been on trial on the North British Railway, is illustrated in Figs. 1 to 6, shown above. The brake as fitted to a four-wheeled wagon is shown in Figs. 1 and 2, while the main part of the mechanism is shown in Figs. 3 and 4, to a larger scale.

The brake, which is designed and constructed by Messrs. Dickson and Mann, Limited, Bathville Steel Works, Armadale, West Lothian, is operated by two short hand levers at diagonally opposite corners of the wagon as is usual in such cases. The levers are carried by stirrup brackets fastened to the solebars. Each lever is prolonged beyond its pivot, and the tail is bent over so as to come in contact with the bracket, thus providing a stop to prevent further movement. The manner in which the brake operates will be readily understood from Figs. 3 and 4, in which the brake shaft and brake rods will be easily recognised, while the pull rods coupled to the hand levers are lettered *a*, *a*. The brake shaft is carried by a pair of stirrup brackets, and above it, carried by cross-bars, is another short shaft having three levers, two of which are coupled to the pull rods *a*, while to the third *b*, is pivoted a rod passing through the centre of a helical spring. At the other end of this rod is a slot in which slides a gudgeon pin. The latter forms the toggle joint for the levers *d* and *c*. The lever *d* is carried at the lower end by the stirrup bracket. The second extremity of *c* is pinned to the lever *e*, pivoted on the fixed bracket at its other end. It will be evident from Fig. 4 that these links and levers *d*, *c* and *e*, are arranged in pairs, and between the pair *e* there extends a small cross-head from which hangs an adjustable rod coupled with the brake lever arm.

The main action of the brake is as follows: When either hand lever is pressed down the lever *b* is rotated to the right (in Fig. 3) with the result that the toggle links *d* and *c* are forced apart and the links *e* lifted. A pull is thus exerted on the adjustable rod, consequently applying the blocks to the wheels. It may be stated that the arm *b* is rotated so far as just to pass the dead centre with regard to the spring rod and toggle pin. The brake is therefore locked and the hand levers will not fly off, although not held by any rack or other arrangement. In releasing the brake either hand lever can be operated so as to return the lever *b* to its original position when the blocks will leave the tyre, the tails on the hand levers preventing excessive movement in this operation.

Combined with the either-side gear is an ingenious compensating mechanism which takes up any wear of the blocks. The chief item of this part of the gear is shown in Figs. 5 and 6, which illustrate the adjustable rod to which we have referred above. This rod is telescopic and embodies an adjusting screw operated by a pawl and ratchet. The ratchet is connected by means of a rod and universal coupling, with a cross-bar between extensions of the levers *d*. The action will be evident. When the mechanism is operated the ratchet is pulled or pushed by the levers *d*. If play exists the screw is turned with a consequent shortening of the rod. If the wear of the blocks becomes sufficiently great for it to do so the pawl will slip over and engage a fresh ratchet tooth with which it will remain engaged till the blocks are further worn.

The actual braking pressure is obtained by means of the long helical spring, the lever *b*, it will be remembered, being rotated just over its dead centre. The spring presses the toggle pin to the right (Fig. 3), this pin sliding in the slot in the rod carrying the spring. The brake is designed to exert a maximum pressure of 6,000 lb. on the brake blocks, and the shunter cannot exceed this, thus preventing skidding. By means of an auxiliary spring a force of about 1,000 lb. can be applied. The leverage works out at about 100 to 1, and the force actually required at the hand levers, to apply the brake, as measured by a spring balance, is about 60 lb., which can easily be exerted by a man using either hand. No pole to obtain increased leverage is necessary.

The automatic take up eliminates a great deal of time spent in adjusting the ordinary form of brake, while the gear permits of a new block being fitted to one wheel only, if the other is not completely worn out. When in the "on" position the pressure exerted on the blocks is practically constant over a considerable distance, in spite of wear, on account of the action of the helical spring. On an incline the shunter can apply or release the pressure gradually as required. The arrangement can be adapted to power braking with the Westinghouse or vacuum systems.

"DANGERS IN THE USE OF ACETYLENE."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of January 5 (page 21), under the heading "Dangers in the Use of Acetylene," a review is given of a pamphlet recently issued by the Factory Department of the Home Office entitled "Memorandum of Dangers from the Use of Acetylene Gas and in Oxy-Acetylene Welding in Factories." It cannot be denied that the issue of this authoritative word of caution is timely, but it is hoped at the same time that the dangers referred to and precautions recommended will not act as a deterrent to those desiring to take advantage of the use of the oxy-acetylene process.

In this connection we would take the liberty of drawing your attention to what has perhaps escaped the notice of the reviewer, viz., that the dangers and precautions almost entirely refer to acetylene generators and the use of calcium carbide, whilst it is definitely stated that "there is less risk of explosion in connection with the manipulation of cylinders of dissolved acetylene than with acetylene generators." This official recognition of the comparative safety of acetylene when compressed in cylinders is moreover endorsed by the special Home Office Order in Council which exempts the method of storage and the process of compressing from the provisions of the Explosives Acts.

In view of the important bearing which the use of the oxy-acetylene flame and its value in relation to heat treatment have upon the questions of mechanical construction and repair, we feel that this re-assurance would be of interest to a great number of your readers.

Yours faithfully,
For and on behalf of ALLEN-LIVERSIDGE, LIMITED,
A. B. HARROWER.

106, Victoria-street, London, S.W.1,
January 8, 1923.

A WORKER'S VIEWS ON THE CRUSHING BURDENS ON INDUSTRIES.

TO THE EDITOR OF ENGINEERING.

SIR,—Relief from the burdens that are strangling industries plays little part in the thoughts of the labour leaders who stir large audiences, and even the House of Commons, with the hardships of inadequate wages. I would therefore like to state the case from the worker's point of view. I hold that an aggravation of the evil would result if the State were to provide subsidies or enforce a wage large enough to afford the comforts in view. Subsidies would impoverish the taxpayers, bring the Government to a standstill, and destroy industrial initiative and energy: for a slackening of stroke must result in an increase of the subsidy. A statutory wage would produce the same result on labour efficiency; and it would choke industries by raising prices above the level of those charged by rivals and beyond the means of domestic purchasers. These burdens may be tolerable when trade is booming, for then wages and other items of cost merely follow prices. Producers

have a claim on a share of the benefits which accrue from wars or the free play of economic forces, but with the decline of prices the burden-bearing strength of industries diminishes, and an attempt by the workers to maintain wages and other burdens at the highest figures would only bring disaster on them and the industries.

A great increase of these burdens has been effected since the outbreak of war, though workmen are singularly oblivious of this change. The oldest of them is the Workmen's Compensation Act, which was much increased by an increase of the allowances during the war. Not only is there little prospect of a return to the smaller payments made in pre-war time, but the Government are pledged by their predecessors to changes that must make the burden heavier. As showing how the burden steadily increases it is only necessary to mention the disease nystagmus, that has become a great source of outlay in the mining industry. Workmen, however, pay for the benefits accruing from this Act, though they are not quite conscious of the liability. They must retire prematurely from work owing to increase of liability to accident and to tardy recovery from the effects of an accident. Men who, though good workmen, are approaching old age are terrorised by the thought of the hardships resulting from the loss of employment. And the plight of aged workmen is the force that has brought old-age pensions into operation, there being now a menacing demand for the raising of the pension to 1*l.* a week and to commence at the age of 60. While large bodies of employers must maintain doctors to check malingering, trade unions must employ agents to supervise the claims for compensation, so that the system imposes a heavy burden on both parties. Societies, like the Miners' Permanent Relief Societies, could have provided adequate support to the disabled without so heavy a cost and with much less hardship to all parties.

Health Insurance and Unemployment Insurance came into operation at a later period and have added substantially to the burdens on industry. Under Health Insurance workmen were promised 9*d.* for 4*d.*, but as they contribute the 4*d.* the State providing 2*d.*, the burden on the industry is 3*d.* per man per week. The only gain to the workmen is the State's contribution of 2*d.* per week, the 3*d.* which the employers are assumed to contribute being taken from the workmen as if it were paid directly to an official of a Friendly Society. Working men assume that because the money comes through the industry the draft does not diminish the wage-paying capacity of the industry, but on thinking the matter thoroughly out they would find that while the burden depresses wages it hampers the industry. Unemployment Insurance acted in the same manner until the system of special grants became necessary, and then it was a terrific burden on taxpayers as well as industry. Workmen seem to think that the dole should be large enough to maintain the ordinary standard of living, and that employment should be provided at trade union wages. The net result to the mass of workmen of this system is that the unemployed do not compete for employment, so that wages are maintained against the pressure of an extraordinary number of unemployed. Workmen, however, who derive this benefit do not think they should contribute to the cost. While the miners raise a great cry about their poverty, they overlook the benefit derived from the sacrifices by the public on their behalf, never stopping to contemplate their plight if the unemployed had been forced through hunger to accept work on any terms employers chose to offer. With this state of affairs in existence, unemployed workmen would have, with the assistance of friends in distant countries, been hurrying across the ocean. But they remain in the country to continue the turmoil about the hardships of those who cannot exactly get all they want without doing a little work, and who will, in the course of a few years, produce a class that will lower the standard of industrial efficiency. These people detract the workers, destroying the incentive to effort and poisoning at their source common ideas of the value of labour.

The remaining great burden on industry is that of rates—municipal and poor law. It has been the special object of labour since the outbreak of war to make this burden as large as possible. Wages of unskilled workers have been raised above the level of the skilled; salaries have been raised to fabulous figures, and poor relief has been administered on a scale unknown in past times. Unemployed have received an income above that of full-time workers and people who, though not unemployed, were needing help were treated in a similar manner. Besides that a craze was manifested for relief works that would create employment and improve the trade of districts, and rates reached enormous figures, house rents and cost of living keeping pace in the upward movement. When rates rose a long way manufacturers and retailers had to adjust their prices so that income would meet expenditure, and with the resultant rise of cost of living the demand was made for higher wages and allowances to meet the increase of costs. The public are quite familiar with the actual increase; what is needed just now is to make clear the results of the increase on industries and wages, and then the fact will emerge that industries are being pushed to ruin by this rapidly-increasing burden. Our high prices enable our rivals to capture our trade, and a further loss results from the prices being above the purchasing power of our domestic consumers. Even in a single trade, such as coal, the increase as shown by figures that have been frequently published, are startling.

Engineering must suffer more than any other single industry from an increase of this burden. To the increase of the cost of coal, iron, steel and transport must be added the increase on this industry; and then we may wonder how the industry can compete against the German and Belgian industries which are not troubled with extra burdens of this kind. More wonderful still is the fact that the workmen who enthusiastically increase rates and taxes do not seek to reduce the burdens when trade depression has made relief necessary in some form. The remedy then is a State subsidy. This proposal has not yet been advanced by the engineering employer, but opinion is moving in that direction. Their second means of relieving industry is that of maintaining prices at the old rates regardless of the effect on trade. These leaders probably imagine that, when the shipping and kindred trades have regained the normal activity, the engineering trade will prosper as it always did in the past, but they overlook the point that whenever trade prosperity has caused wages to rise trade depressions have brought them down. In these olden times the burden of poor and municipal rates was not much in men's minds as there was small thought of taxing ratepayers heavily in the interest of the right to live. While workmen are learning that these schemes for regaining prosperity to industry can do no good, industries are stagnating under the weight of the crushing burdens mentioned, and when employers are compelled to exercise force for the purpose of cheapening producton and recapturing the ground occupied by rivals, a cry is raised by the trade unions that employers are using the strength derived from severe trade depression to cripple the unions and lower the standard of living among the workmen. Pathetic appeals are issued to the public for help in resisting the onslaught. These are the sort of difficulties that gather round the men who risk their capital and exercise their skil. in maintaining the industries by which the people live.

Yours faithfully,

"A WORKING MAN OF THIRTY-FIVE YEARS' STANDING."

January 1, 1923.

"EXPLOSION OF A VERTICAL BOILER AT A FARM."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the article in your issue of November 10 last (page 583), dealing with the report of a preliminary inquiry, No. 2,575, held under the Boiler Explosion Acts, 1882 and 1890, regarding the explosion of a boiler at Romford, I am directed by the Board of Trade to state that, owing to an incorrect statement on the part of one of the witnesses, the supply of the boiler in question was wrongly attributed to Messrs. T. W. Ward, Limited, and that the report has been withdrawn for correction and reissue, Messrs. Ward having, in fact, had no connection whatever with the case. The Board would therefore be glad if you would publish this correction in the next issue of your paper.

I am, Sir, your obedient servant,

C. H. BOYD.

Mercantile Marine Department, Board of Trade, 3, Sanctuary-buildings, Great Smith-street, London, S.W.1., January 4, 1923.

"THE EDUCATION OF ENGINEERS."

TO THE EDITOR OF ENGINEERING.

SIR,—Your contributor, Mr. Beck, uses an expression —"the acrobatic exploits of 'i,'"—which does not seem very suitable in a serious article. In pure mathematics only functions of the first degree can be fully treated without the symbol. Electrical engineers must learn the elements of complex algebra in order to read Steinmetz's classical text-books, and aeronautical designers must have some command of the elementary theory of functions to follow recent developments of aeroplane theory with its brilliant successes. Other applications suggest themselves readily.

What comparison then can there possibly be between knowledge of this powerful method and wilful mispronunciation of simple English words as Mr. Beck suggests? He only does harm by encouraging non-technical engineers to despise what they do not themselves understand, and comes too near the level of the imported American witticisms about the "X-chaser" and the "slip-stick (slide rule?) merchant," which can still set backward drawing offices in this country in a roar.

Yours faithfully,

A. R. L.

"MATHEMATICS AND GEARED DRIVES."

TO THE EDITOR OF ENGINEERING.

SIR,—I would like to draw attention to a few more errors and mis-statements appearing in Mr. Eagle's letter which you published December 1, 1922 (page 673). I am particularly anxious to take these out of the controversial field.

He states that I neglect the elasticity of the propeller shaft, but subsequently he modifies this and does not appear to be quite sure what I really do. A careful reading of the paper will easily clear this point.

In his very next deduction on the character of the disturbance produced by a three-bladed propeller he is unfortunately in error. A reference to Fig 13 of Messrs. Thorne and Calderwood's paper (N.E.C.I., November 17, 1922) will clearly show this.

Although he states that he has now read my paper, it is quite clear that he has only read about one-half of it. His remarks on the $2\,n^2\,m + n$ item are interesting and his discovery of critical speed ranges somewhat surprising. He appears to have finished his reading at this point. Otherwise he would have seen in the next sentence the following: "Item 4, all the critical speeds of an n one mass per shaft system can be collected into n distinct groups . . . It would appear, then, that there are n critical speed ranges in which it is impossible to secure continuous running without taking serious risks."

My conclusions, seven in number, are not at the end of my paper, but in the middle. These are the items to attack, but they are the items which Mr. Eagle most carefully avoids.

In some manner, he has formed quite wrong ideas on tuning, periodic action and pitch lowering. I cannot understand these ideas and do not see that any useful purpose would be served by an attempt to understand them.

My paper was built up simply and solely on the assumption that the disturbing actions were all periodic. The chief object of my investigation was to devise the simplest possible means of reducing the unworkable ranges both in numbers and magnitude. It was not my intention to reduce the matter to a popular form. If the work appears cumbersome it is simply owing to the nature of the investigation, when a popular account is required I will supply it. I think Mr. Eagle will agree that this would be much better than leaving it to someone who has never read or tried to understand the published paper. The work has been developed a great deal further than is shown in the published statements, but I have followed the ordinary normal procedure of engineers. I made no attempt at publication until long after the main conclusions had been submitted to reasonable tests, both in the laboratory and in an experimental ship. Even then I only published the part which I wished to have checked. I consider this method to be the only safe course to adopt in engineering work.

An unbiassed engineer who is responsible for a large number of geared ships, has recently investigated the whole history of our experimental ship. In his opinion there is less wear in two years' continuous running of this ship than he has met with in 2 hours in most of the ships with which he has had to deal. Again a large geared turbine ship (probably the largest afloat) fitted with a drive designed on the lines laid down in my paper, covered 6,000 miles at full speed on her maiden voyage.

If Mr. Eagle has any new ideas on the subject it is his business to put them to the test. If he is successful in producing satisfactory drives and if he publishes his work as a complete unit and not in instalments, I shall be one of the first to congratulate him. In the meantime, after carefully reading his original paper and the subsequent correspondence, I see no reason to modify a single sentence which I have written.

Mr. Eagle's is correct on one point at least, I am chagrined. This feeling is solely due to his injudicious choice of words and ideas. That such things can be introduced into a discussion of this kind by a man who is connected with my Alma Mater is really beyond my comprehension. It is for this reason that I must refuse to discuss the matter further.

Yours faithfully,

J. H. SMITH.

Municipal College of Technology, Belfast, January 4, 1923.

PROPOSED WHITWORTH SOCIETY.—A meeting will be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, Westminster, at 6 p.m., on Friday, January 12, to consider the formation of a Society of Whitworth Scholars and Exhibitioners. All Whitworth Scholars and Exhibitioners are cordially invited to be present.

PERSONAL.—Mr. C. H. Wordingham, C.B.E., M.Inst.C.E. (of 7, Victoria-street, Westminster, S.W. 1), has removed his Manchester office from No. 11, Mosley-street, to more centrally situated offices at 33, Brazennose-street. His telephone number, viz., Central 828, remains as before. Mr. R. W. Willis, M.I.E.E., is his assistant in charge at Manchester.—The Yorkshire Copper Works, Limited, Leeds, have opened their own offices at 53, New Broad-street, London, E.C.2.

THE ISHERWOOD SYSTEM OF SHIP CONSTRUCTIONS.—A tabular statement issued by Mr. J. W. Isherwood, 4, Lloyd's-avenue, E.C.3, shows that in 1922 the ships built, under construction and on order, on the Isherwood system, numbered 1,431, for a deadweight carrying capacity of 12,101,890 tons, figures which compare with 6 ships and 31,608 tons from September, 1907, to December, 1908, and with 240 ships and 1,777,348 tons for the year 1912.

BUSINESS WITH CHILE.—H.M. Chargé d'Affaires at Santiago, Chile, in a recent despatch to the Department of Overseas Trade, calls attention to the importance of United Kingdom firms interested in Chilean Government contracts keeping the various Government Departments in that country supplied with copies of their catalogues and other trade literature. Any catalogues which it may be desired to supply to these departments should be posted to them direct. A list is available at the Department of Overseas Trade, 35, Old Queen-street, S.W.1.

ELIMINATION OF MISFIRING OF CENTRE SHOTS.—As a means toward the elimination of misfiring of centre shots in large-scale blasting in coal mines, the United States Bureau of Mines recommends that the following practices be used whenever shots are to be fired in wet holes: Use waterproofed electric detonators with enamelled leg wires. When making connections with enamelled leg wires, care must be taken to scrape the ends of the wires well, otherwise the enamel will prevent good electrical contact. Fire the shots from an ungrounded power circuit that has a capacity of at least 30 kw. Use extra care when tamping the holes in order not to damage the insulation of the leg wires. Arrange the connections between the detonators so that they are supported clear of the earth or any other conducting medium.

JIGS AND TOOLS.*

By J. MOORE, A.M.I.Mech.E.

THE importance of jigs and tools to modern engineering with the intensified production now made necessary by the competitive market, needs no description or explanation here. The difficulty consists rather in formulating good practice in the design of jigs and tools, consistent with the needs and requirements of every branch of the industry.

In view of the vast field covered by the various kinds of articles manufactured and the peculiarities that are centred around each particular case, the difficulties in attempting this will be readily conceded.

The first consideration in designing a jig or fixture is to provide for correct machining with the minimum operating time. For instance, it is not good practice to design a jig from the point of view of cheapness, even in sufficient quantities to keep a special machine going, and more often than not, in such cases the special machine would be more simple in design than a standard machine purchased for the same purpose. Without taking a concrete example as a basis for comparison, it is difficult to indicate the difference between the two types of machines, but taking a small capstan lathe, on which the turret automatically revolves on the return of the slide, there are on the standard machine probably six turret holes. Supposing, however, that the job on which the machine is continuously used only requires four holes, time is lost in indexing, and there is also a considerable waste of energy on the part of the operator. If, on the other hand, the quantities required justified the use of a special machine, the number of holes in the turret, the number of stops, and the speeds and feeds provided would not exceed the requirements of the one job.

In this connection the author has seen substantial economies effected by the practice of duplicating the turret tools on small capstan lathes, so that by using two sets of three tools, two parts are finished at one cycle.

Similarly standard automatics with the various movements essential for a large range of work are frequently run continuously on some simple job which could be done equally as well on a simple single-purpose machine. In such cases money would be saved in the initial cost, and would not be tied up in the cost of the various attachments that usually go with a standard machine.

Another point that frequently arises in connection with automatic machines is the questionable practice of asking the shops to set up for small batches, on which sometimes the setting-up time would very nearly equal the total machining time. The author would suggest that the progress department should be provided with setting-up times for all automatic machine work, and that a percentage basis should be fixed, so that when the percentage of the setting-up time with regard to the machine time exceeded a certain limit the work should be transferred to a turret, capstan or centre lathe, according to which machine was most suitable for the job. In a similar manner in connection with turret lathes, simple jobs that could be done in practically the same time on a centre lathe, equipped with a square turret fitted to the tool slide, should be transferred to machines of this class.

Another important question that should be dealt with before proceeding with the design of jigs and tools is the consideration by a production committee of all important pieces immediately after design, from the point of view of manufacture. Very useful work can be done by such a body in facilitating the tooling, with perhaps the addition of spotting bosses, &c., to castings or stampings to simplify location. Also by the introduction of slight modifications at this stage, faces which are inaccessible for machining purposes may be avoided, and the machining may be simplified in other ways. On such work it is not advisable to pass over simple-looking pieces too readily, since these frequently prove afterwards to be tricky and difficult to handle.

The preliminary to jig and tool design should always be the lay-out of the various operations through which the piece has to pass, and there is room for the exercise of considerable skill in this section of the work. Further, foresight at this point will frequently enable standard equipment to be employed, without impairing manufacturing efficiency. For this purpose, in the works with which the author is connected, a special card called the "Lay-out Card" is used. This is shown in Fig. 1, and it will be noted that nine columns are provided for entering tools, tool description, operation description, name of machine, machine symbol, department number, set-up time and time allowed.

In any operation where the person responsible for planning considers that a special jig or tool is necessary or desirable, he enters in column 2 the jig or special tool required.

Also in the case of a milling operation, he may state that two rows are to be machined at a time, or in multiple drilling he may indicate the number at each setting, and so on. This is intended for a guide to

Part No. N.12202

Jig and tool drawing office

OPERATION LAY OUT

TYPE 4 NO. OFF 1

PART NAME Radiator stay fork end. L.H. MATERIAL Steel List No 9 DATE 21.9.1922

OPER. NO.	TOOLS	TOOL SYM.	OPERATION	NAME OF MACHINE	M/C SYM.	DEPT. NO.	SET UP TIME	TIME ALLOWED HRS.	TIME ALLOWED MIN.
1	Collet		Face turn drill and first tap cut off	Bar lathe	BTA	27			5
2	Fixture		Mill fork	H. Mill	HMB	21			3½
3	Fixture. Cutter		Radius head	H. Mill	HMB	21			2
4	Jig		Drill hole	S. Drill	SD	21			1½ each
5			Burr and tap note to gauge			38			2
6			Stamp Part No			38			1 each
7			Final view						

FIG. 1. OPERATION LAY-OUT CARD.

A 10102 TOOL LAYOUT

OPER. NO.	OPERATION	MAC. SMB.	DEP. NO.	FIXTURE	IND. NO.	DEP. SZE.	TOOLS	IND. NO.	DRG. SZE.	GAUGES	IND. NO.	DRG. SZE.	ALTERATIONS
12	Drill tap and face holes in head of Bores, Chamfer Expansion Head, Drill and tap holes for Valve Cover and drill and tap for drain. Tap for valve caps.	BDC A	21	Drill Jig (valve cover)	-9B	LD	Tw. drill 30·5 m/m Facing bar S.L.691 Facing Ctr. S.L.699 1" Gas tap S.L.781 Tap. 56 m x 12 thds. p. 1" (for valve caps) S.L.782 A Pearns Topper "B" C/Boring Tool C/Boring Tool holder Tw. drill 3/8" 7/16" B.S.F. Tap. S.L.784 1/2" B.S.F. Tap. S.L.784 27/64" Tw. drill Pearns Topper "A"	Stk. -10 -14 -20 -28 Stk. -12B -12A Stk. -5 -6 Stk. Stk.	D	Screw thread Gauge 1" gas S.L.732 Screw thread Gauge 56 m x 12 thds. S.L.729 Screw thread Gauge 7/16" B.S.F. St. 728 A Screw thread Gauge 1/2" B.S.F. St. 728 A	-8 -9B -5 -6		

PART NAME "Y" Type Cylinder

MATERIAL Steel list NO. 17.

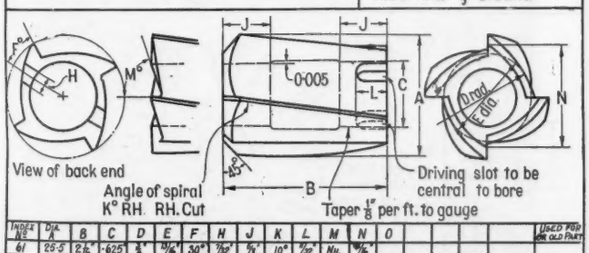
Date 27-7-1921, 28-12-1921

TYPE Y NO. OFF 1

PART NO. A.10102 Sheet NO6

FIG. 2. TOOL LAY-OUT CARD.

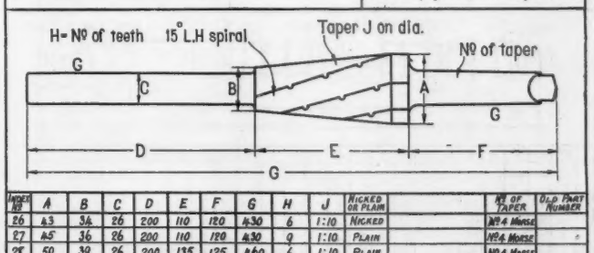
LIPPED SHELL CORE DRILL — MATERIAL H.SS Hnd & Ground



INDEX NO.	DIA. A	B	C	D	E	F	H	J	K	L	M	N	O	USED FOR OR OLD PART
61	29·5	2¼"	·625"	¾"	9/16"	30°	7/32"	5/8"	10°	7/32"	NIL	9/16"		
62	29·5	2¼"	·625"	¼"	⅞"	30°	7/32"	5/8"	10°	7/32"	NIL	9/16"		
63	32·5	2¼"	·75"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	9/32"	NIL	11/16"		
64	40·5	2¼"	·75"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	9/32"	NIL	11/16"		
65	41·5	2¼"	·75"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	9/32"	NIL	11/16"		
66	36 Ref	2¼"	·75"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	9/32"	NIL	11/16"		
67	34·5	2¼"	·75"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	9/32"	NIL	11/16"		
68	31·5	2¼"	·625"	1¼"	1 5/16"	30°	7/32"	5/8"	10°	7/32"	NIL	9/16"		
69	45·5	2¼"	1·00"	1⅛"	1 3/16"	30°	9/32"	¾"	10°	7/32"	NIL	11/16"		
70	29·5	2¼"	·625"	1¼"	⅞"	30°	7/32"	5/8"	0°	7/32"	30°	NIL		

FIG. 3. TYPICAL STANDARD LIST; SHELL CORE DRILLS.

TAPER REAMERS — MATERIAL C.S (Pyros) Hnd & Ground



INDEX NO.	A	B	C	D	E	F	G	H	J	NICKED OR PLAIN		Nº OF TAPER	OLD PART NUMBER
26	43	3½	26	200	110	120	430	6	1:10	NICKED		Nº4 MORSE	
27	45	36	26	200	110	120	430	9	1:10	PLAIN		Nº4 MORSE	
28	50	39	26	200	135	125	460	6	1:10	PLAIN		Nº4 MORSE	
29	50	44	20	200	135	126	400	9	1:10	PLAIN		Nº4 MORSE	
30	56	40	30	10¼"	6°	5¼"	21¼"	6		NICKED		Nº4 MORSE	
31	56	44	30	9¼"	48°	5¼"	19¼"	9		PLAIN		Nº4 MORSE	
32	45		26	130	116	4¼"		9	1:8	NICKED		Nº4 MORSE	
33	52	39	30	120	105	120	345	6	1:8	NICKED		Nº4 MORSE	
34	53	44	32	110	90	120	320	6	1:10	PLAIN		Nº4 MORSE	
35	16·5	SEE SEPERATE PART SHEET							1:11·6	PLAIN			
36	23·9	16·5	15 RUN	60	120	80	260	7	1:8	PLAIN		Nº2 MORSE	

FIG. 4. TYPICAL STANDARD LIST; TAPER REAMERS.

though it may only be required for a small batch of parts, if it will prove expensive to manipulate or if it will give indifferent results, and it is certainly very bad practice to design an elaborate and expensive jig that does not give first-class results in the machining or handling time. It may be argued that the tool cost depends upon output, but the deciding factor should always be the quality of the work and the quantity that will be produced in a given time.

Jigs and tools, it will be conceded, are of the first importance for successful production, but another kindred factor is the type and quantity and quality of machinery in the shops to do the work allocated to them.

Undoubtedly there is a large and varied market to draw upon for equipment, but in the author's opinion the standard machine does not meet the requirements of every case, and it is advantageous to consider special and single-purpose machines in cases where the quantity justifies it. There are in many factories certain jobs

* Abstract of paper read before the Institution of Production Engineers on January 4, 1923.

the designer, and enables him to decide definitely how to proceed.

The information in columns 4, 5 and 6 is also necessary to the designer before commencing, because, in milling fixtures, he must tenon the base to suit the machine, and for lathe work he must know the particular machine so that he can arrange the necessary adaptation of the fixture for it. Before this card was introduced, it frequently happened that where the process and rate-fixing departments had counted upon the provision of a jig or special tool, none had been made when the shops were ready to start upon the job.

Having settled all these details, the designer can proceed to think out the jig, and the successful designer must be an imaginative person. He must not only visualise the construction of the jig, but he must also in a similar manner anticipate all the movements that may be necessary by the operator in using it. Since there are frequently half a dozen ways of doing the same job, it should be his object to select the one that will give correct results with a minimum amount of handling time. This last point is a very important one, and does not always receive due attention. It is obviously bad practice to have, say, a loading time of 3 minutes on a piece which perhaps only takes 2 minutes to machine. There are times, of course, when this is unavoidable, when the piece is difficult to locate, or awkward to clamp, but a little ingenuity on the part of the designer can minimise many difficulties and provide for reasonably quick operation.

Having studied all the preliminaries, the designer will have come to a decision as to the essentials of the design; and the author considers it to be always the best practice to rough out the design only, and submit this to the chief designer for approval. At this stage it is also good practice to review the more important jigs with the chief of the process department, since this gives him the opportunity to see the type of jig which is to be used, and to make sure that it is in accordance with the schedule laid down by his department. Incidentally, this procedure may bring up for discussion difficulties that sometimes occur in jigging to suit the process, and at other times it may bring to light the fact that improvements can be effected in the process. These questions are dealt with at this point, and the necessary modifications made in the process or tooling to satisfy both parties. When such matters are dealt with in a broad-minded manner, the results cannot but be in the right direction.

Having the jig launched, so to speak, well on its way, the question of cost must be borne in mind, and to minimise this it is necessary so to arrange the design that a minimum amount of time will be spent on the jig in the tool-room.

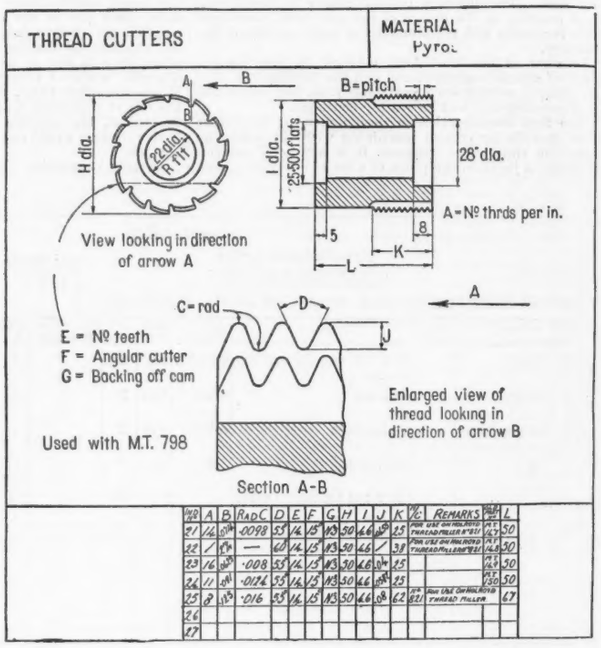
for clamps, feet for the jig, and, in fact, everything possible, should be added to the pattern if it will help to reduce the tool-room costs. Elaborate designs with irregular outlines in the jig body should always be avoided; they may be very pleasing to the eye, but are costly in the pattern shop. Rigidity in the main casting is most important, however, particularly in milling fixtures. Frail castings frequently settle or change their shape, which is a serious matter in boring fixtures and drilling jigs.

Where multiple bushings are employed, square faces which can be machined on the body of a jig are a great help in the tool-room in the jig-making. Similarly if a peg must be located in a hole in the jig body in a certain fixed position, a flat on a collar on the peg abutting against a corresponding flat on the jig is preferable to the usual key in the hole, since it is easier for the toolmaker, particularly if the peg requires to be hardened, when the flat can be ground to give a correct fit in the required position. Standard bolts for clamps, with a channel in the jig to prevent the head turning round, should also be used wherever possible in preference to studs, because, when the thread has stripped and a new bolt is necessary, the operator can insert a new one himself, whereas to extract and replace a stud the jig would need to be sent to the tool-room. If studs must be used, however, the threaded end that screws into the jig body should be made a little longer so that a thin nut may be fitted to lock the stud in position; this prevents studs screwing out when slackening the clamping nut.

While dealing with the question of tool-room costs, a point arises that does not receive sufficient attention

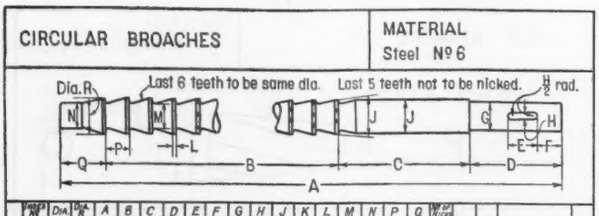
holes to the jig, which will enable the jig borer to insert plugs, to gauge from, for the essential positions on the jigs.

This is an important matter, and is not only an aid to correct jig-making but at the same time helps to reduce the tool-room cost. Another provision which



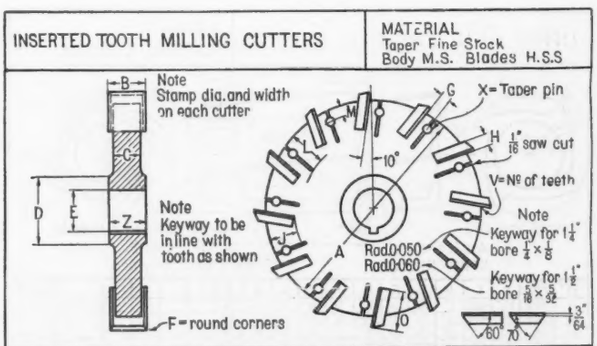
№B	A	B	RadC	D	E	F	G	H	I	J	K	№G	REMARKS	№B	L
21	¼	5/16	·0098	55	¼	·15	·193	50	46	05	·25		FOR USE ON MILLED THREAD MILLER № 611	M.T. 147	50
22	/	⅜	—	60	¼	·15	·193	50	46	/	·38		FOR USE ON MILLED THREAD MILLER № 611	M.T. 148	50
23	16	7/16	·008	55	¼	·15	·193	50	46	06	·25			M.T. 149	50
24	11	7/16	·0124	55	¼	·15	·193	50	46	06	·25			M.T. 150	50
25	8	1/2	·016	55	¼	·15	·193	50	46	08	·62	621	FOR USE ON MILLED THREAD MILLER		67
26															
27															

FIG. 5. TYPICAL STANDARD LIST; THREAD AND MILLING CUTTERS.



Inch №	Dia.	Dia. R	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	Wt. per 100
1																		
2																		
3	22·6	22·63	84·5	715	75	55	20	15	20	5	21·4	1·25	2	17·5	17	13	20	4
4	22·6	22·63	800	650	75	55	20	15	20	5	21·4	1·25	2	17·5	17	13	20	
5	25·1	24·11	810	650	74	66	24	18	22	6	23·9	1·25	2	17·5	19	13	20	
6	28·2	28·24	875	700	84	66	24	18	25	6	27·1	1·25	2·25	22	21	14	25	4
7	28·5	28·54	875	700	84	66	24	18	25	6	27·4	1·25	2·25	22	21	14	25	4
8																		
9	36·7	35·81	1010	800	107	77	28	21	32	7	34·9	1·5	2·25	28	27	16	26	4
10	34·5	34·54	955	750	103	77	28	21	27	7	30·4	1·25	2·25	24	22	15	25	4
11	34·7	34·85	955	750	103	77	28	21	27	7	30·9	1·25	2·25	24	22	15	25	4
12	33·5	33·54	1000	800	97	77	28	21	32	7	32·4	1·25	2·25	25	24	16	26	4
13	34·2	34·24	1044	800	101	77	28	21	32	7	33·1	1·25	2·25	26	25	16	26	4
14	35·1	35·14	1000	800	97	77	28	21	32	7	34·0	1·25	2·25	27	26	16	26	4
15	35·25	35·29	1000	800	97	77	28	21	32	7	34·15	1·25	2·25	27	26	16	26	4
16	36·5	36·54	1010	800	107	77	28	21	32	7	35·4	1·25	2·25	28	27	16	26	4
17	37·5	37·54	1010	800	107	77	28	21	32	7	36·4	1·25	2·25	29	28	16	26	4
18	38·5	38·54	1010	800	107	77	28	21	32	7	37·4	1·25	2·25	30	30	16	26	4
19	39·5	39·54	1020	800	117	77	28	21	32	7	38·4	1·25	2·5	31	30	16	26	4
20	40·5	40·54	1140	900	124	88	32	24	37	8	39·4	2	2·5	31	30	17	26	4
21	41·5	41·54	1140	900	124	88	32	24	37	8	40·4	2	2·5	32	31	18	26	4
22	42·6	42·54	1140	900	124	88	32	24	37	8	41·4	2	2·5	33	32	18	28	5
23	43·5	43·54	1150	900	134	88	32	24	37	8	42·4	2	2·5	34	33	18	28	5
24	44·5	44·54	1160	900	144	88	32	24	37	8	43·4	2	2·5	35	34	18	28	5
25	45·5	45·54	1160	900	144	88	32	24	37	8	44·4	2	2·5	36	36	18	28	5
26	46·5	46·54	1160	900	144	88	32	24	37	8	45·4	2	2·5	37	37	18	28	5
27	47·5	47·54	1210	1000	151	99	36	27	45	9	46·5	2	2·75	37	37	20	30	5
28	48·5	48·54	1210	1000	151	99	36	27	45	9	47·5	2	2·75	38	37	20	30	5
29	49·6	49·54	1210	1000	151	99	36	27	45	9	48·5	2	2·75	39	38	20	30	5
30	50·5	50·54	1210	1000	151	99	36	27	45	9	49·5	2	2·75	40	39	20	30	5

FIG. 6. TYPICAL STANDARD LIST; CIRCULAR BROACHES.



Inch №	Cutter Dia.	A	B	C	D	E	G	H	J	L	M	O	P	V	X	Z	Old Part № R.
31	230	210	20	16	6¼	1¼	9	3/8	28	31	10	38		14	5/16	20	
32	230	210	26	19	6¼	1¼	9	3/8	28	31	10	38		14	5/16	26	
33	230	210	30	22	6¼	1¼	9	3/8	28	31	10	38		14	5/16	30	
34	230	210	35	26	6¼	1¼	9	3/8	28	31	10	38	2 1/32	14	5/16	35	
35	230	210	37	27	6¼	1¼	9	3/8	28	31	10	38		14	5/16	37	
36	242	222	35	26	6¼	1¼	9	3/8	28	31	10	38		14	5/16	35	
37	242	222	35	26	6¼	1¼	9	3/8	28	31	10	38		14	5/16	35	
38	254	234	38	28	6¼	1¼	9	3/8	36	33	11	48		15	5/16	38	
39																	
40	268	244	38	28	6¼	1⅜	9	7/16	36	33	11	48	2 1/16	16	5/16	38	
41	268	244	40	30	6¼	1⅜	9	7/16	36	33	11	48		16	5/16	40	
42	280	256	38	28	6¼	1½	9	7/16	36	33	12	48		17	5/16	38	
43	286	262	42	31	6¼	1½	9	7/16	36	35	12	48		17	5/16	42	
44	292	268	36	26	6¼	1⅜	9	7/16	36	35	13	48		17	5/16	36	
45	292	268	45	33	6¼	1½	9	7/16	36	35	13	48		17	5/16	45	

FIG. 7. TYPICAL STANDARD LIST; INSERTED TOOTH MILLING CUTTERS.

So far as the experience of the author goes built-up jigs are costly, and except for the simple type of jig which perhaps can be made from a slab of cast-iron, a standard angle plate, or a piece of mild steel cut from the bar, a pattern should be made, and all bosses, heels from all designers. It frequently happens that a bushed hole in a drilling jig, or a setting face on a milling fixture, can only be dimensioned from a datum line, and the designer can often reduce the difficulties of the tool-room in locating the correct positions by adding one or two the designer should always make on milling fixtures is a fixed setting gauge, or gauges, for correctly setting the milling cutters.

In a similar manner gauging blocks are sometimes necessary for spot-facing in drilling and boring fixtures,

and these, wherever possible, should be added to the pattern, and therefore cast solid with the jig body.

In dealing with forgings, stampings and castings the question of preliminary marking out for setting purposes arises, and it might be mentioned that at the works of the Associated Equipment Company, Limited, up to some twelve months ago, a large number of men were continuously engaged on lining out, until the management decided that this heavy expense could be saved. The onus thus fell on the jig and tool office to find a way out of the difficulty, and the author is pleased to say that, except for one or two very isolated cases, marking out has been eliminated. This question merits general attention, and when tackled seriously it will be found that good results can be easily obtained. The jig location for this class of work should never be of the fixed type, owing to the ever-changing sizes that occur in stampings, as wear takes place on the stamping dies. This is sometimes met by periodical alteration of the locating points, but after this has been done from time to time the stamper may suddenly decide to use new dies, and it is then necessary to alter the jig locations back to the original position. Set screws with check nuts to lock them are frequently used for this purpose, whilst in the case of boss locations, adjustable vee plates may be employed for centring. If fixed plates must be used, then the screw holes should always be elongated to allow for adjustments to suit each batch of stampings.

Similar remarks apply to castings which vary, due to slight difference in new patterns, or a difference in the two or more patterns which are used simultaneously. Another frequent cause of trouble is excessive rapping of the pattern in the moulds. Also, in connection with this class of work, due regard should always be paid to the clearance allowed for the stamping or casting in the jig. Trouble in this direction may be avoided if the designer pays sufficient attention to the various positions which the component will occupy in loading the jig.

With regard to drill bushes in drilling jigs, the author considers that case-hardened mild steel, correctly treated and hardened, is superior to cast steel, because with mild steel a glass hard surface is obtained which resists wear better than cast steel. Due regard should also be paid to the depth of bushings, and for deep hole drilling, and always on slip bushes, a flat on the head and a stop pin in the jig should be provided. This prevents the bush from lifting or rotating in the jig and wearing out the lining bush.

While discussing drilling jigs, a few words may be said regarding multiple drilling operations. On pieces with holes of various sizes, some of which perhaps have to be reamed and others tapped, one frequently observes a multiple machine employed where it is doubtful whether it is a paying proposition, because the drilling time that may be saved can easily be absorbed in resetting up on a radial or single spindle drill to complete the operation. The alternative for this mixed class of work consists in completing the operation at one setting on a single spindle machine.

It has frequently occurred to the author that all makers of multiple drilling machines have not paid much attention in the past to this particular point, and he has wondered why they have not arranged the multiple drilling machine with a change-speed motion that would enable combined drilling and reaming operations to be performed. To explain this point, supposing there were six holes to be drilled at one setting and a 12-spindle machine was available, one setting would be for drilling on the high-speed and the other setting for reaming on the low speed. The advantage which would be obtained is obvious.

Up to this point the jig designer will in most cases

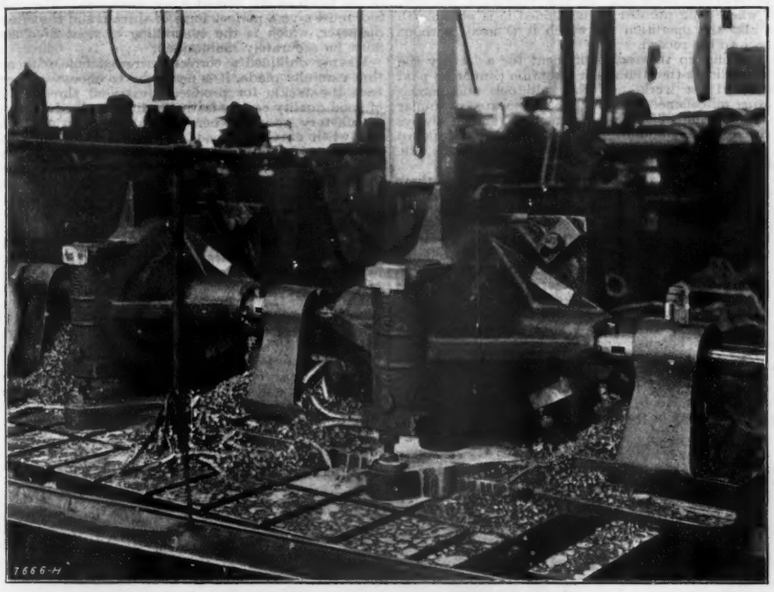


FIG. 8. BORING OPERATIONS ON REAR AXLE CASINGS.

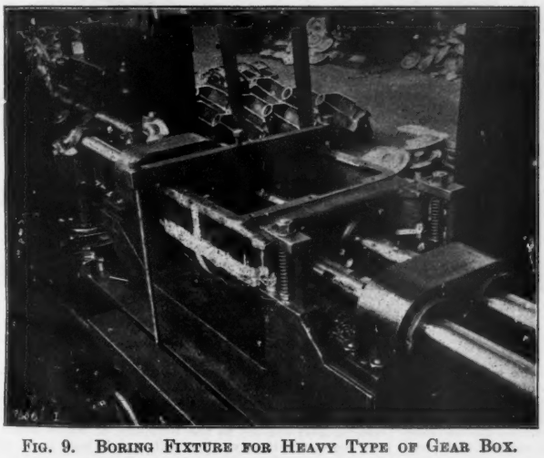


FIG. 9. BORING FIXTURE FOR HEAVY TYPE OF GEAR BOX.

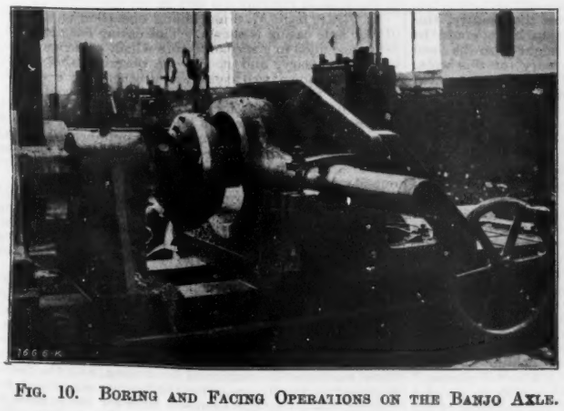


FIG. 10. BORING AND FACING OPERATIONS ON THE BANJO AXLE.

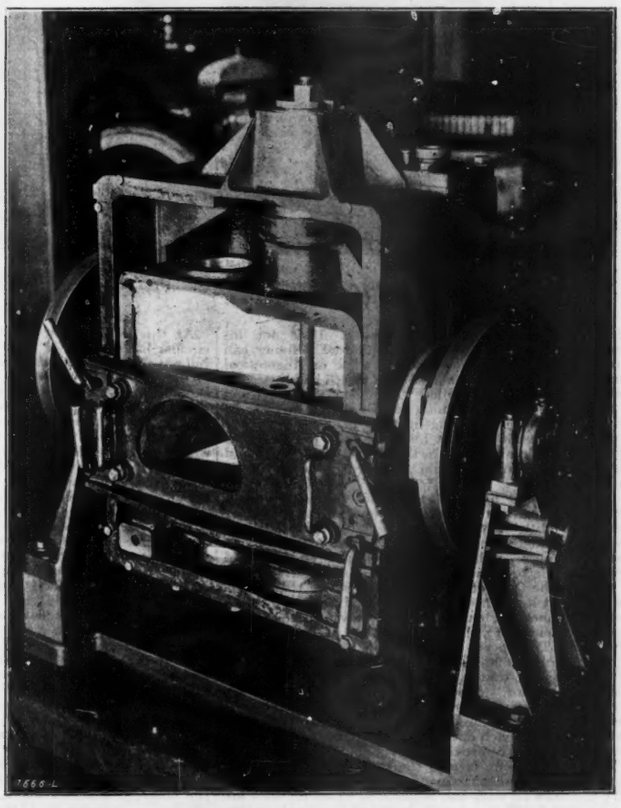


FIG. 11. A TRUNNION FIXTURE FOR BORING GEAR BOX.

have worked from paper to paper, that is to say, he will have drawn out on paper a jig for machining a part, of which he has seen only a blue print, and certain defects may appear in the jig when made which did not occur to him when the drawing was on the board. Whilst this cannot at any time be accepted as an excuse for faulty design, these imperfections do occasionally creep in. It is in this connection that the jig demonstrators who should always be attached to the jig and tool department prove useful, and any defects that may occur to the demonstrator, such as casting clearance, ineffective clamping or locations, can be rectified at this stage. Also tests for rigidity on milling fixtures when under cutting stress, &c., can be carried out, thus ensuring that when the shops draw the jig from the stores' shelves it will be in thorough working order, and that no time will be lost in putting it into operation.

When a jig has been successfully demonstrated a report is made out, on which are entered all the necessary particulars concerning the operation, and the form is finally signed by the foreman of the department in which the jig is to be used. The time occupied for demonstration is entered, together with the total time allowed the operator, and under the heading of "Remarks" the demonstrator will comment on any defects he may have found in the jig, or, on the other hand, suggest any improvements which he may consider could be embodied in it. This form is afterwards passed into the chief designer's office for his consideration, and he may possibly rearrange the jig drawing ready for any subsequent issue.

The shops now have had a jig provided for their use, which has been built up on what might be called the theory of the designer, a theory that is tested in a practical manner by the demonstrator. It is not intended to imply here that a jig and tool designer can educate himself for this kind of work on theoretical knowledge only, because such a man would be practically useless in a tool drawing office. He must always have had a thorough practical training in the shops, in fact, he cannot have spent too long in them if he is to achieve the best results, and whilst his home is in the jig office, his mind should always be in the shops, which he should visit frequently in connection with any job he may have in hand.

One important matter that should be mentioned in connection with this subject is the question of providing the shops with an official list of all the jigs, fixtures, tools and gauges that will be required to machine a particular piece. When a jig or tool has been made and sent to the stores ready for issue, a tool advice note is sent to the foreman of the section where the jig will be used, but it has frequently happened that, due to the indirect connection between the tool advice note and the operation concerned, this special tackle was not brought into use. To prevent this, and at the same time to provide the foreman and operators with an official list of all the tackle that is necessary for a given operation, the "tool lay-out," shown in Fig. 2, is made out. It will be noted on reference to this that it is arranged in the order of the operations, and columns are provided for entering against each operation number the jigs and tools and gauges that are provided for each.

This tool lay-out is also the designing office official record, and for their reference the letters in column 7 give the drawing sizes and indicate in which file they are to be found. The original sheet, which is of tracing paper, is typed with a special ribbon on the typewriter, and when completed prints are taken and pasted on to millboard, so that copies may be sent to the various substores in the departments concerned. It is then the duty of the foreman and operator to consult these lists and withdraw from the stores all the tackle that is recorded upon them, and incidentally they act as a guide to the storekeeper of all the tools he should have on his shelves ready for issue. It will be noted on referring to this list that some of the tools are numbered under the part number with an added index number. These tools are, of course, specially designed for the particular piece, the index number, which is for office purposes, being always selected according to the operation number. Thus, when a jig number is mentioned it is possible to know also the operation for which it is used, without reference to the record.

In building up the tool equipment for a factory the author considers that too much attention cannot be paid to standard list work, and that all tools and gauges and other miscellaneous items that are repeated in similar form, but perhaps of different dimension, should always be placed on a standard list. Examples of standard lists which are outside the usual lists of drills, taps, &c. are shown in Figs. 3 to 7.

In the firm with which the author is connected there are standard lists for tools of various kinds, and the advantages are many. Our first act upon tooling up a job is, of course, to consult these lists to see if there is anything existing that will do; if not, it takes very little time to add the necessary dimensions in the tabulated columns for the new tool required. The standard list tools are always grouped together in the stores under their list number, whereas in the case of tools marked with the part number they are kept on the particular shelf allocated to that part. Thus it has frequently happened that because none of these particular component parts have been passing through the shops for machining, these part number tools have remained on the shelves for very long periods out of use, whereas the standard list tools, which are not locked up in the same manner, may be frequently employed on other parts.

FIG. 12. THE ARRANGEMENT ADOPTED FOR FRAME DRILLING.

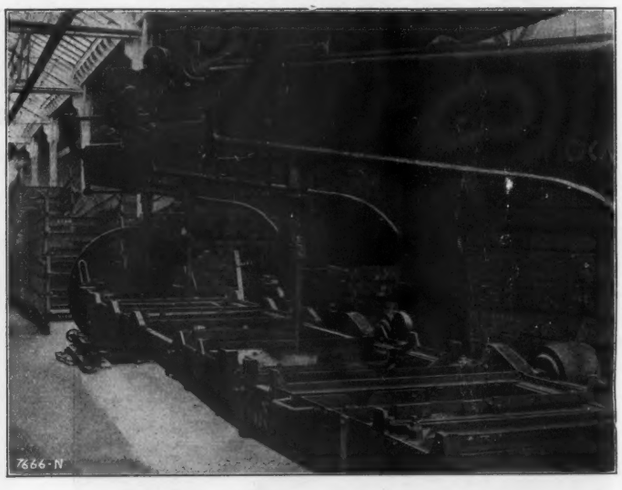


FIG. 13. THE FRAME IN ITS DRILLING FIXTURE.

At this point a few words might be said regarding circular broaches, since the author is of the opinion that full advantage is not taken of these tools in many shops. It may be that the process departments in such shops cannot induce the management to purchase the necessary machines, or perhaps they have never realised the possibilities of such tools, but certainly from the author's observations, and, further, from conversations he has had with different engineers up and down the country, this accurate and cheap method of sizing holes could be more frequently adpoted. Much might also be said about screwing and the tackle necessary for this work, which is, by the way, the bane of the tool equipment engineer's life, since it is undoubtedly the most difficult and troublesome operation of all. This remark will be fully appreciated when it is mentioned that at our works the limits fixed for screw gauges by the National Physical Laboratory are considered too wide, and have been cut down by 50 per cent., and only screwed work fitting gauges made to this narrow margin will pass the inspection departments.

The difficulty of working to such limits has caused us to reconsider our methods of gauging screw threads and to adopt other means than the commonly-used ring and plug screw gauge. With this type of gauge a "feel fit" of the work to the gauge is called for, and it is impossible to tell exactly where contact is taking place. It may be on the top or on the core diameter of the thread, or perhaps the screw may be of incorrect pitch, when only the two extreme threads in the gauge will be in contact. In either case the threads will be thin and the effective diameter small, with no definite check on the mechanical strength of the screw. The "Wickman" type of screw thread caliper gauge appeals to us as a more correct method of checking all the elements of the screw and maintaining a definite mechanical strength.

With regard to taps, these illustrate a case where design takes second place and workmanship in the tool-room is of first importance. The difficulties that are encountered in tap-making might well be the subject of a separate paper, but brief reference may be made to some of the salient points. The steel used for taps must be of a special kind, with, when it is possible, the quality of not shrinking in hardening, whilst the machine for cutting the thread should have a compensating device to allow for any expansion or shrinkage that may occur in the pitch of the thread when hardened. The cutting tool must give a perfect form of thread, and the effective diameter, which is the controlling element of a screw, must be accurately maintained.

Having obtained a correctly-screwed hole with a tap thus carefully made, it is necessary to choose with equal care the tackle for producing external threads. Dies of good quality can be fairly readily obtained which give satisfactory results when carefully set in die heads, but when cutting threads without a die head chasers are preferable to single point tools, which are slower in action and not nearly so accurate for quantity work. Similar care must be exercised with regard to screw gauges, and these should always be hardened or toughened to prevent bruises when handling.

A few examples of jigs used for motor lorry work are illustrated, these jigs having satisfactorily withstood the test of practical application in the manufacture of rear axle casings and banjo axles. At this point the method of finishing the crank-case main bearings may be mentioned. For this purpose the line reaming of the bearing after assembling in the crank-case was introduced at the request of one of the directors of the company to dispense with any necessity for scraping the bearing, which is the usual method of bedding the crankshaft. In this manner an operation which might occupy as much as two days under the old methods is performed satisfactorily in a few minutes.

A further instance of accurate machining carried out on the connecting rods may be mentioned. In this case the connecting rods and caps are interchangeable in every respect, since the rods and caps are not bored and stamped in one piece in the usual manner. This remark also applies to the bearings, of which any half will register with any other half, and in both these cases the tolerance allowed from the joint face to the diameter in the bore of the cap is 0·002 in.

In Fig. 8, page 57, a machining operation on a S-type of rear axle casing is shown. This casing has previously been machined in a special fixture which renders marking out unnecessary, and it may be observed that in the operation shown two cases are arranged on a tandem fixture so that both may be bored simultaneously.

The boring fixture for a heavy type of gear-box is shown in Fig. 9 in position on the machine on which it is used; two bars are employed simultaneously, being drawn through the casing and coupled to the machine spindles, and the operation includes the turning of the outside diameter of the extended boss.

A further operation on this component is illustrated in Fig. 11, page 57, which shows the method of boring the selector rod and reverse stud holes in a trunnion fixture. This fixture provides for indexing the casing through 180 deg., so that after operating on one side the casing is turned over and bored from the opposite side.

Fig. 10 illustrates one operation on the banjo axle, and shows a method of boring and facing the banjo, which might perhaps have been done on a large lathe or a boring mill had there been one available. Another interesting operation is that of drilling the frame, the arrangement for which is shown in Fig. 12 above. In this case three machines are employed for drilling, and the frame is placed in the fixture, after the jigs are assembled, for drilling 130 holes, the complete time for the operation, including loading and unloading, being 60 minutes. The frame is shown in a horizontal position in Fig. 13.

A few weeks ago the author had the opportunity of attending a lantern slide lecture on the methods employed by the L.G.O.C. at Chiswick in the overhaul of motor vehicles which were made at Walthamstow. At the

depot, the workings of which were shown on the screen. Some 80 vehicles are overhauled weekly, and it was interesting to watch the wonderfully rapid way in which the chassis were dismantled and reassembled again, and while none of the speakers at the lecture alluded to the point, the author thought that the remarkably easy manner in which everything was put together was a splendid although silent tribute to the interchangeable work turned out at Walthamstow. It afforded him considerable satisfaction to have watched this exhibition of expeditious assembling of parts, which one could safely say was undoubtedly the result of good jigging and careful inspection.

Before concluding, the author would like to say that he realises that the jig and tool question is almost an inexhaustible one, and to emphasise again the difficulty of setting up general principles for a branch of work that has so many varieties.

CATALOGUES.

Electric Riveting Machines.—A catalogue of electrically-driven riveting machines of the portable and stationary types, giving particulars of the sizes made and current consumption, together with a fully-illustrated description of the working parts is to hand from the Mada Engineering Company, Limited, Liverpool.

Oil Switches.—The switchboard-mounting pattern of oil switches for controlling and protecting feeder circuits, transformers, generators and motors, is fully described in a revised catalogue issued by Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7. Particulars of the standard switches made by the firm are also included.

Steam Shovels.—Messrs. Ruston and Hornsby, Limited, Lincoln, send us two catalogues containing very full particulars of their steam shovel and universal excavator. Full specifications are given with descriptions of all essential parts and methods of operation. Both the details and the complete equipments at work are illustrated.

Air Compressors.—Air compressors ranging from 2 h.p. to over 200 h.p., in fixed and portable types, with direct-steam, motor or belt drives, are dealt with in an exceedingly well-compiled catalogue issued by Messrs. Broom and Wade, Limited, High Wycombe. The catalogue covers a very wide range of forms suitable for all the usual applications.

Oil Storage.—A complete plant for storing, pumping and measuring oil is described in an 8-page quarto pamphlet, issued by the Dowson and Mason Gas Plant Company, Limited, 3, Manchester-street, London, W. The plant includes special trucks for carrying and tipping barrels and machines for automatically delivering measured quantities.

Water Filter.—A drifting sand filter in which the filtering medium is automatically and continuously undergoing a cleansing process is described in a catalogue issued by Messrs. Vickers, Limited, Broadway, Westminster, London, S.W. The description of the process is carefully compiled and will be useful to those in charge of water purifying plants.

Laboratory Furnace.—A catalogue describing a single-tube electric furnace suitable for such work as the combustion method of estimating the carbon content of steel, determining the critical point in steel and other alloys, standardising pyrometers, &c., has been received from the Leeds Electrical Construction Company, Limited, Charmouth-street, Leeds.

Air Extraction from Feed Water.—Boiler feed-water is much less corrosive to iron and steel if the air and oxygen in solution are extracted from it. Messrs. Hick, Hargreaves and Co., Limited, Bolton, have devised a plant for effecting this de-aeration automatically without the use of chemicals, and have issued a catalogue illustrating and fully describing the system.

Pure Iron.—An interesting pamphlet has been issued by the Scottish Tube Company, Limited, 34, Robertson-street, Glasgow, describing iron, of over 99¼ per cent. purity, explaining its merits for tube and sheet purposes, and dealing with the method of working it in flanging, &c. The iron, which can be produced uniform in quality, is highly resistant to corrosion and has good physical properties generally.

Electric Generators and Motors.—A catalogue of standard open-type continuous-current generators and motors received from Messrs. Bruce, Peebles and Co., Limited, Edinburgh, contains lists of machines ranging from 22 h.p. to 1,750 h.p., suitable for various voltages, and also gives a lucid description of the principal parts. A list of firms and authorities at home and abroad using these machines is also printed.

Portable Air Compressor.—A portable air compressor, mounted on a four-wheel truck and forming an independent power unit for operating three or four pneumatic riveting hammers, or two road-breaking tools, is described in an illustrated circular received from the makers, Messrs. Lacy, Hulbert and Co., Limited, Beddington, Surrey. The components are a two-cylinder petrol engine, compressor, radiator and receiver.

Concrete Mixing and Moulding Machines.—Messrs. Winget, Limited, Winget House, Grosvenor-gardens, S.W.1, have sent us four catalogues dealing with a portable wet concrete mixer of 4 cub. ft. capacity with engine mounted on a four-wheel truck; a similar machine of 2½ cub. ft. capacity; a chain-spade mixer of 4 cub. ft. capacity in portable or in fixed belt-driven form; and a fixed belt-driven machine for moulding bricks, slabs, tongued blocks, &c. Ample descriptions and illustrations are given in all cases.

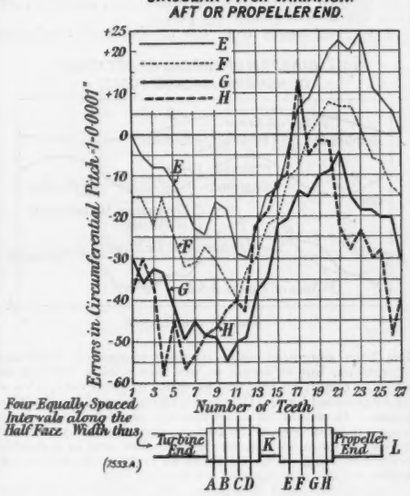
A PARTIAL DISCUSSION OF THE VIBRATIONS OF MARINE GEARED TURBINES.*

By JOHN H. MACALPINE.

Introduction.—It gives me a very genuine pleasure to accede to the valued invitation of your president and Dr. Suyehiro to contribute a paper for the twenty-fifth anniversary of the founding of the Society of Naval Architects of Japan, many of whose members I have the honour of counting among my personal friends. I send my greetings to the society with the sincere wish that it may long continue to render its efficient service to the advance of naval architecture.

The question of vibration in marine geared turbine installations has gradually become more prominent in the last twelve years. It has shown its presence in many cases by excessive noise, and in some by very high pressure which caused marking of the large gear teeth in zones, and no doubt it was a contributing cause in not a few cases of fractured teeth. This spring it was a special feature at the meetings of the Institution of Naval Architects, London, where two related papers were read and discussed: one on "Nodal Arrangements of Geared Drives," by Dr. J. H. Smith, and the second on "Double Reduction Gears in the S.S. Melmore Head," by Mr. J. Wilkie.† Dr. Smith's paper is a mathematical investigation of the natural periods of vibration of a marine geared turbine installation, and was undertaken to find a solution of the great vibration difficulties, causing excessive noise and deterioration of the teeth, which had occurred in the S.S. Melmore Head. Mr. Wilkie's paper is a detailed account of these difficulties and the various steps which were taken to overcome them. The efforts were quite successful, and Dr. Smith arrived at a solution which he calls the "nodal drive," a special adjustment of the torsional elasticities of the whole reduction gear, made with the object of reducing

Fig. 1. DIAGRAM OF CIRCULAR PITCH VARIATION. AFT OR PROPELLER END.



the critical periods to the smallest number. He makes no attempt to evaluate the importance of the various critical speeds, and this omission has, I think, caused a great and unnecessary complication of the whole subject and a failure to discover a very great danger in nodal drive. But the fine public spirit shown by Dr. Smith and Mr. Wilkie, and also by the owners and builders of the Melmore Head, in putting fully on record their costly experiences, persistent efforts against discouraging difficulties, and patient investigations, cannot be too highly praised. It could hardly have failed to prevent many disasters, and the present naturally perturbed state of feeling in Britain regarding gears, among ship-owners and builders of rigid gears, had all interested been equally frank.

I have for many years—since I was a young engineer under Dr. Kirk in Robert Napier and Sons, Glasgow—been deeply interested in the question of vibration of machinery and ships, the forces exciting vibration and the causes limiting its growth. Naturally, when making the drawings of the first floating-frame gear, nearly sixteen years ago, I gave careful thought to the subject, and saw no reason to fear that serious disturbance would occur with the elastic construction there adopted, though I made no critical analysis. That conclusion has, happily, been justified. But on the early trials of U.S. Destroyer Clemson, fitted with floating-frame gears, these proved excessively noisy, and it was suggested that there was severe torsional vibration present. It seemed unlikely that the noise was due to synchronous torsional vibration as it began at a small power and increased, showing no distinct maxima at definite speeds. But I undertook to calculate, from very exact data of this installation, what the speeds for synchronous torsional vibration of this ship were.

The Westinghouse Company also instituted a series of tests to discover the exciting cause, and it was ultimately found to be a short period error in the cutting of the gear teeth. When this was corrected by recutting the teeth the noise disappeared and the machinery of the Clemson and her 33 sister ships, engined by the Westinghouse Company, have proved eminently satisfactory.

But the possible occurrence of serious vibration in gearing had been frequently suggested, and it threw little light on the subject merely to calculate the natural periods of torsional vibration of the shafting. All machinery vibrates, and factors of safety in almost all cases amply allow for the increased stresses. But it seemed most important to investigate the circumstances under which vibration would become dangerous. I therefore proposed to myself what seemed to me the simplest, but perhaps most illuminating, problem connected with this large subject. Suppose that the teeth, instead of being exactly cut, were distributed in any manner around the circumference of the gears and pinions, and making a reasonable supposition regarding the actions which would damp the vibrations, what will be the amplitudes of the resulting vibrations and the stresses induced?

I began working on this question of torsional vibration, beginning with the earlier problem of discovering the natural periods, in March, 1919. It has been carried on am d many interruptions and, indeed, I have not been able to touch it for many months. It is not yet nearly as complete as I hope to make it, but I see no prospect for early completion, especially as the numerical work is laborious. I have only investigated single reduction with one, two, or any number of pinions actuating the gear wheel; but the investigation of double reduction is of the same nature, only more complex. I shall in this paper state some of the considerations involved and some of the results reached. I will deal especially with two sets of cases:—

(1) The effect in a two-pinion gear when that portion consisting of the turbine rotors and elastic shafts, through which the turbines actuate the pinions, are (*a*) "in tune," and (*b*) "out of tune."

(I use the expression "in tune" in the same sense as Dr. Smith does. Let one of the pinions be held from rotation and an axial torque, such as the steam exerts, be applied to its turbine rotor and suddenly released. The resulting torsional vibrations of the rotor and shaft are, say, at the rate of n_1 per minute. Treating the second pinion and rotor similarly gives n_2 vibrations per minute. If $n_1 = n_2$ the two elastic shafts and rotors are "in tune," and if they are not equal they are "out of tune.")

(2) The effect in a four-pinion gear actuated by, say, two high-pressure and two low-pressure turbines, when (*c*) the two high-pressure rotors and their elastic shafts are in tune and, similarly, the low-pressure elements in tune, and (*d*) when they are all out of tune.

It is now quite obvious why I have called this a partial discussion. Indeed, it can hardly be called a discussion at all as I merely state results, omitting all analysis. It must not be looked on as a discussion of Dr. Smith's valuable paper for, as I have just returned from abroad, the time left at my disposal to write this paper is very short and does not afford the opportunity to follow Dr. Smith's elaborate mathematical analysis which, I am sure, is perfectly correct. I have carefully read the non-mathematical parts of his paper and the discussion. I am induced to put forward my results as they seem to me to throw additional light on his and in some cases to modify his conclusions.

Causes Exciting Vibration.—There are two principal sources of excitation of torsional vibration of the shafting of a marine geared turbine:—

(1) The variation of pitch of the teeth, expecially in the large gear, but possibly sometimes in the pinions.

(2) The variable torque due to the variable resistance of the water to the motion of the propeller blades.

(1) Even in the best-cut teeth there will always be a variation from perfection; and this, under conditions of exact or approximate synchronism, may give rise to torsional vibrations causing a considerable rise of stress in the shafting. This variation in well-cut gears is very small, never involving the displacement of any part of any tooth from its correct position by more than a few thousandths of an inch, even in a gear of large diameter.

The errors will usually be distributed very irregularly round the circumference and on different sections, as is shown by the diagram, for a pinion, contributed by Mr. Guy to the discussion of Dr. Smith's paper.* and reproduced here as Fig. 1, which is self-explanatory The measuring instrument used is one of remarkable accuracy, but any slight error of this instrument or of observation will appear in these curves. It gives an easily read indication for 0·0001 in.

It is principally the mean circumferential error we are interested in here and this may readily be found by drawing a curve on the circumference as axis of abscisse, whose ordinates are the mean of the errors along lines parallel to the pinion or gear axis, such as KL, Fig. 1. The resultant curve will give very accurately the errors of rotation of the hobbing machine table. Over a year ago the Westinghouse Company sent me the measurements of a pinion of 6·697 in. pitch diameter which they had cut for a floating-frame gear supplied to the Metropolitan-Vickers Electrical Company, Limited, and measured by the latter on the same very accurate machine as was used to obtain Fig. 1. The mean values of the errors for this pinion are shown by curve C, Fig. 2. The accuracy of cutting of this pinion Metropolitan-Vickers consider quite good. These small errors can be analysed into their simple harmonic elements. That of first period will pass through one complete cycle in one circumference of the large gear or pinion, the second will complete two cycles in one circumference, the third

* Paper read before the Society of Naval Architects of Japan, October, 1922.

† ENGINEERING, vol. cxiii, pages 438, 467 and 469. For the discussion see page 445.

* ENGINEERING, vol. cxiii, page 446.

three cycles, and so on. Sine curves D and E show the first and second period curves of errors, and in F the ordinates are the sum of those of D and E. Comparison of curves C and F show that there are many other periods very sensibly present. The large residual errors between circumferential stations G and H are obviously due to the combining of several short-period errors of comparatively small amplitude.

As the very approximate differential equations of torsional vibration are linear, each period error will give rise, independently of the others, to vibrations of its own period. If the elastic state of the gear is such that it very readily responds torsionally to 300 impulses per minute, the first period errors of the large gear will most readily set up torsional vibration when it is revolving at 300 r.p.m.; the second period error of the teeth of this gear will most readily set up torsional vibrations of 300 per minute when it is revolving at 150 r.p.m.; the third period error, when revolving at 100 r.p.m.; and so on.

Similarly, where the pinion is revolving at 300 r.p.m., its first period (second, third and so on, periods) will tend to set up torsional vibrations at 300 per minute; but if the ratio of reduction is, say, 5 to 1, this will happen at 60 r.p.m. (30, 20, and so on, revolutions per minute) of the main gear. This would usually be at a low power. Besides, the linear errors of pitch of the pinion teeth which are due to errors of rotation of the table of the gear-cutting machine would be only one-fifth of those of the main gear, if cut on the same machine. Hence the effect will be small in most cases if the gears are well cut.

It is not quite correct to take the mean circumferential readings, as is done in Fig. 2, since undoubtedly the action may be increased somewhat by more local errors. These are the cause of the polishing of teeth commencing in spots, and they tend to disappear. These errors are due to several causes—for instance, errors of the slide of the hob carriage or of the screw driving this carriage, or nearly any error in the hobbing machine mechanism; except, perhaps, those contributing to variations of the turning of the table, which will recur almost exactly every revolution and appear in the mean curve C, Fig. 2. The errors of rotation of the table are angular and will have about the same amplitude for large and small gears cut on the same machine. The others are mostly linear and should be less important for large gears than for small or pinions, thus making the mean value nearer true when considering the main gear wheel. The mean value is truer also for floating-frame than for rigid gears, since misalignment is so frequently present in the latter, as experience has abundantly demonstrated. This gives hard bearing over a portion of the teeth and the irregularities of spacing for that portion will be the most effective in exciting vibration.

Inaccuracies of the teeth will cause the contacts to be made usually with a finite velocity normal to the tangent plane at the points coming into contact. In other words, a blow will be struck. The intensity of this blow and the resulting noise will increase with the intensity of torsional vibration and therefore should be a maximum when synchronism is established. But it is important to observe that it will always be present, even if there is no sensible torsional vibration. Supposing no such vibration, the noise will still increase from two causes:—

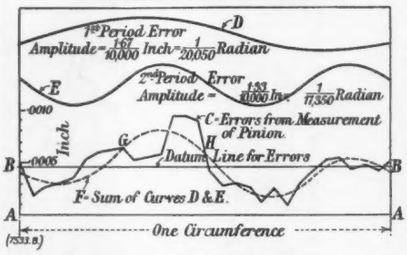
(*a*) Obviously, with the increased imperfection of the tooth cutting.

(*b*) With the moment of inertia of the parts involved in striking the blow. The massive large gear may be looked on as the anvil, and the pinion and parts very rigidly attached to it as the hammer. This illustration is at least roughly true. If the pinion is actuated through an elastic shaft (called the "quill drive" in Britain, when this shaft passes through the pinion) as has always been done in floating-frame gears, we have only the very light pinion involved. Therefore, floating-frame gears are not "roarers" (to use Dr. Smith's very expressive term) with the notable exception of the Clemson, which was quieted by correcting the shape of the teeth. Hence her case proves the truth I am now enforcing. But if the pinion is very rigidly attached to the turbine rotor, as has usually been done in rigid gears, we increase the weight of the hammer immensely. For instance, the moment of inertia of the Clemson's high-pressure turbine rotor is 82 times that of its pinion and the low-pressure turbine rotor 186 times. This is a most important part of the explanation of "roarers," and I may note here that the introduction of an elastic shaft on the low-pressure side of the Melmore Head at once stopped the noise and vibration on that side, at all speeds apparently, before the corresponding change was made on the high-pressure side; that is, before nodal drive was established. We are told by Mr. Wilkie that "The hammering of the gears had entirely disappeared at the low-pressure side, and instead, a pure rolling of the teeth was produced."* The latter part of this quotation seems to assume, I think with insufficient ground, that the teeth had a very perfect shape and that the noise had been all due to torsional vibration. The same low pressure gears had previously hammered their way six times across the Atlantic. Referring to the action of these same low-pressure gears, before the elastic shaft was introduced, it is stated that "a reduction of the constant (tooth pressure per inch ÷ √pinion diameter) from 274 to 132 had not produced that smoothness of running and absence of noise so essential for the preservation of the gear for any considerable time."* It is hardly credible that the teeth, even if perfect when cut, were in very good condition after that prolonged hammering. Again, no doubt there was some confused torsional vibration present, but there seem to have been no speeds of maximum noise which would clearly indicate this. I think it is unquestionable that the action which ultimately communicates audible vibration to the air is almost entirely a transverse movement of the particles of metal in the gear; largely, perhaps, of these considerable and nearly flat central surfaces of the main gear. Even if all the critical speeds of torsional vibration which Dr. Smith indicates, are important, the possible modes of transverse vibration of the whole gear are very much more complex, and a response will always be obtained to blows delivered at any speed. My impression, from my recent visit to many noted marine engineers and shipowners in Britain, is that the quill drive is rapidly gaining favour and with good reason as it largely separates the question of alignment of the turbine from that of the gear and, as I have tried to show above, reduces very largely indeed the hammer action.

(2) Returning to the variable torque of the propeller: This is very considerable, even in a calm sea; and if the propeller is correctly made, one cycle of the torque variation will occur as many times in a revolution as there are blades in the propeller; that is, if the propeller is running 100 r.p.m., and has four blades, there will be 400 cycles per minute. As the variation will be more or less of the nature of a shock, it may be analysed into simple harmonic variations of 400, 800, 1,200, &c., per minute, each of which will tend to set up torsional vibrations of its own period. If the propeller is badly made, or broken, the 100 and 200 (and, possibly, 300) per minute periods will appear. Unfortunately we know little of the character of these variations of torque, and they differ greatly for different ships and propellers. If the sea is rough the variable impulses from the propeller will be irregular and, consequently, over a sufficient time to give rise to torsional vibrations, analysis may show impulses of almost any period.

A varying torque from the turbine each revolution

Fig. 2. DIAGRAM OF ERRORS OF ROTATION OF HOBBING MACHINE TOOLS.



has been suggested as a possible source of torsional vibrations, but it seems to me that with a turbine in running condition this will be quite unimportant, a view also expressed by Mr. Guy in his discussion of Dr. Smith's paper. It would be of extremely short period. In a single reduction gear the turbine runs from, say, 5 to 16 times, or more, as fast as the propeller, and in a double reduction from 40 to 50 times as fast. I do not think these are the periodicities we need to fear.

Causes Damping Vibration.—No machine could run unless vibrations were damped. The number of its natural periods is enormous, and under synchronous impulses each corresponding vibration would continue to grow indefinitely. Each of the myriad of dark lines in the solar spectrum denotes a natural period of vibration, but it also tells both of the absorption and dissipation of energy without which everything, apparently, would disintegrate.

The principal causes of damping which need be considered in gears are:—

(1) The resistance of the water to the motion of the propeller blade. This increases very quickly with the speed, no doubt on account of the intense vortex motion which is present. Mr. Hermann Frahm, in his admirable paper on the synchronous torsional vibrations of propeller shafting finds that the resistance of the water to the variable turning of the propeller varies nearly as the fourth power of the instantaneous speed.† The fourth power is assumed in the calculations I have made.

(2) Waste of energy in the turbines. I know of no experiments directly bearing on this case, where a small vibration is superimposed on the mean speed of rotation. This cannot fail to disturb the steam flow and increase the vortex action. I have made what, I think, is the minimum reasonable assumption:—

$$T = A\,(V_m - V)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where T = the variable torque,
A = a constant,
V_m = the mean velocity of rotation, and
V = the variable velocity due to vibration.

Equation (1) states that T decreases when the total velocity of rotation, $V_m + V$, increases which, I think, will always be true when the vibration is of short period and at all violent. The question has but slight connection with the efficiency-speed curve where, with increasing steam flow, speed, and power, the efficiency rises. Another practically equivalent form of equation (1) is:

$$T = \frac{A\,V_m^2}{\left(1 + \frac{V}{V_m}\right)^2},$$

since $(V/V_m)^2$ and higher powers are quite negligible. This will, perhaps, make the law appear more probable. It might be anticipated that the function would be more nearly

$$T = A\,(V_m + V)^n,$$

where n is some positive quantity; but this obviously would make steady rotation unstable, and I know of no observations which indicate this at any speed. I will be glad if attention is directed to this important question and well-founded data obtained. The ratio V/V_m is so small that the torque can certainly be expressed with accuracy by some such function of the velocity in any particular case. Whether this index (2 in equation (1)) would be nearly constant for a large range of V_m may be disputed; but, as bearing some analogy, it may be pointed out that, over a long range, the resistance of a ship—when that resistance arises principally from skin friction; that is, ultimately from vortex action, as here—varies nearly as the square of the speed. When the wave-making resistance becomes important, or the ship is driven much over an economical speed, resistance rises more quickly than the square. And the same is true, as Mr. Frahm found, in the action of the propeller, which is very violent. I would expect that if the law held closely for one well-made turbine it would hold for all those well made.

(3) The friction of the bearings. The direction of sliding being always the same it is only the variable part of the bearing friction which would absorb energy of vibration. This I need not stop to prove. As both the variation of speed and radii of the journals are small, and also the coefficient of friction in an oil-borne high-speed journal, the dissipation of vibrational energy will, it seemed to me, be so small that I took no account of it in the cases calculated.

(4) The friction of the gear teeth. This differs in character from the friction of the journals. The speed of sliding varies between zero and a considerable maximum and the friction thus contributes to the absorption of vibrational energy, unless there is a node at the gear wheel. But both the extent of sliding and the coefficient of friction are small. Therefore I have left it out of account. This omission is certainly correct in the case of nodal drive, as then the gear wheel is rotating almost uniformly, and this friction will not sensibly affect the vibration. In other cases possibly the effect may be of considerable importance relative to the absorption by the turbines and propeller, for a preliminary estimate I have made of the rate of absorption of energy of vibration by the turbine and propeller gives this as a small fraction of 1 h.p. when over 9,000 h.p. were being transmitted through one of Clemson's gears—but I make this statement with reserve till fully checked. The propeller was a much more powerful agent of absorption than either turbine rotor.

(5) The internal viscosity of the metal. This is unimportant except for very short period vibrations, and is left out of account in the cases calculated.

To conclude: Probably the assumptions made have caused a slight under-estimate of the rate of absorption of vibrational energy; but it is more nearly true for nodal drive than where the vibration involves the main gear wheel.

Modes of Torsional Vibration.—Two flywheels A and B, Fig. 3, are connected by a shaft held in frictionless bearings. The moments of inertia of A and B about their axis are I_1 and I_2, respectively, and the moment of the shaft section, supposed of uniform circular section, is J.

Let opposite torques be applied to A and B, twisting the shaft, and suddenly released. A and B will vibrate, moving through the initial position of rest at the same time, but in opposite directions. This will go on indefinitely if the vibration is undamped. There will be a nodal plane C in the shaft whose position is given by $l_1 I_1 = l_2 I_2$, l_1 and l_2 being the distances of A and B from C. This equation neglects the usually unimportant mass of the shaft. The angular amplitudes of A and B will be in the ratio of l_1/l_2. The number of vibrations per minute is given by

$$n = \frac{30}{\pi}\sqrt{\frac{\mu g J}{I_1 I_1}} = \frac{30}{\pi}\sqrt{\left\{\frac{\mu g J (I_1 + I_2)}{L I_1 I_2}\right\}} \quad . \quad (2)$$

where L is the total length of shaft, in feet, μ the modulus of torsional rigidity of the shaft material in pounds per square feet, and g the acceleration of gravity in feet per second. This is the only mode of torsional vibration possible if the shaft has no mass; and if the shaft has mass it is the fundamental mode, but the position of the plane C will be slightly altered.

In the next higher mode of torsional vibration A and B pass through the position of rest in the same direction; there are two nodes, one very near A and the other very near B, if the proportions of the shaft and end masses are such as we need consider here. The parts of the shaft between the nodes will pass through the position of rest in the opposite direction to A and B. The speed of vibration will be many times that of the fundamental mode, as is evident from the first two terms of equation (2). Viscosity of the metal will now have risen in importance, and as the angular motion of the portion of the shaft near the centre of its length will be much greater than at A and B, friction of the bearings will also be a more powerful damping agent. The modes with three or more nodal planes are obviously of much shorter period still.

If, now, we replace A by the propeller, B by the main gear wheel, and add a pinion and turbine rotor actuating

* ENGINEERING, vol. cxiii, page 470, bottom of column 3: Since the high-pressure had not yet been tuned when the vibration entirely disappeared from the low-pressure side, I think Mr. Wilkie is not justified in stating, in the second last paragraph of his paper, that the "continued successful running of this gear is entirely due to the tuning of the periodicities of the various rotating masses of the system." As I show in this paper, success is more safely attained without tuning.

* ENGINEERING, vol. cxiii, page 470.

† Journal of the American Society of Naval Engineers, vol. xiv, page 753.

it, the pinion and rotor being very rigidly connected, we have the usual arrangement adopted in a rigid, single-reduction gear. We have still the same case as shown in Fig. 3, but with I_2 increased due to the attached pinion and rotor. Since, before adding the moment of inertia of the pinion and rotor to I_2, we must multiply it by the square of the ratio of reduction, the total moment of inertia at B becomes much larger than that of the propeller A. (If B is actuated by two pinions and a compound turbine the forward moment of inertia is again greatly increased: and with a double reduction of, say, 40 to 1, the inertia of the rotors and parts revolving at the same speed must be increased 40^2, or 1,600 times.) C moves nearly up to B, and the natural period of vibration is lengthened from that of the position of C shown in Fig. 3. B will then participate only very slightly in the angular vibrations of the propeller; though, of course, the stresses will be communicated to it.

We know that in some cases, and probably in many, if not all, it is this fundamental torsional vibration that gave trouble. For the main gear wheel was marked in four zones, showing four recurrences of high tooth pressure per revolution of the propeller, which had four blades; and calculation showed that the fundamental vibration occurred at four times the speed, near which the propeller had been run. Prominence of a higher period would certainly have given a very different marking.

If, now, we introduce an elastic shaft between the turbine rotor and pinion, we have two fundamental modes of vibration, each with its own nodes, or virtual nodes, on the propeller and elastic shafts.* Here, again, it will be obvious that the first harmonics will be of many times shorter periodicity than the fundamental vibrations.

If the turbine is compound, each driving its pinion through an elastic shaft, we have three fundamental vibrations, and harmonics of much shorter periodicity. By "tuning," two, or all three, of the fundamental periods may be made to coincide, leaving two or only one fundamental vibration. The latter is the case of the nodal drive. Similarly, for each rotor and elastic shaft added we add a fundamental torsional vibration, which may, or may not, coincide in period with one or more of the others.

But there is one other case of great importance. In Fig. 3 suppose B rigidly held, and a torque applied to A and released. From equation (2) the number of vibrations per minute is given by:

$$N = \frac{30}{\pi}\sqrt{\frac{\mu g J}{L I_1}} \quad . \quad . \quad . \quad (3)$$

and is graver than that given by equation (2). If now B be forced to execute N small vibrations per minute, A will respond by vibrating with an amplitude which will increase till the ratio of amplitude of A to that of B is very large. If there were no absorption of energy this ratio would increase without limit, since the node is in the limit, at B. If A is the turbine rotor and B the pinion, any cause which applies N impulses to the pinion per minute will produce a greatly exaggerated vibration of the turbine rotor. This period will not usually coincide with that of one of the fundamental synchronous nodes noted above, but they do coincide in nodal drive. Any slight irregularity of the teeth or even minute vibration of the main gear wheel may communicate the impelling vibration to the pinion. I cannot think of a better name for this vibration than "exceptional"; as "exceptional vibration" or "exceptional period." It deserves the most careful consideration, and I early calculated it for the Clemson.

Finally, in a gear in which m turbines each actuate a pinion through an elastic shaft we have fundamental vibrations $n_1, n_2, \ldots, n_m + 1$, and exceptional vibrations $N_1, N_2, \ldots, N_m$. Any number of these may coincide in value, $n_1, n_2, \ldots, n_m + 1$ may be supposed to be arranged in order of graveness, or period, beginning at the longest vibration. The suffixes in $N_1, N_2, \ldots, N_m$, may refer to a numbering of the turbines and, in the case of a high and low-pressure turbine, may be designated N_H and N_L.

For the Clemson the values of n are approximately:—

TABLE I.

—	Starboard.	Port.
n_1	371	363
n_2	465	392
n_3	1,658	1,642

These are calculated without including the mass of the shafting. With the inertia of the line and propeller shafting included calculation shows values only a few per cent., at most, lower. For both starboard and port gears:

$$N_H = 442 \text{ and } N_L = 294.$$

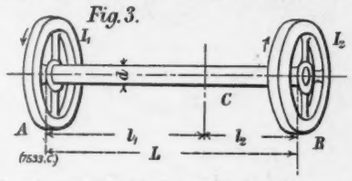
In the calculation 25 per cent. is added to the moment of inertia of the propeller. Mr. Frahm found that to make his observations and calculations agree required an addition of from 20 per cent. to 32 per cent. to allow for the water carried along with the propeller.*

I find that the power assumed in the calculations is a little higher than the Satterlee, a sister ship of the Clemson, developed in her official trials. With the Satterlee at maximum speed, 486 r.p.m. of propeller, the rule adopted in my calculations gives this excess as about 16 per cent., and probably less at lower speeds; but I have not the full data. This difference does not seem to me important.

In the case of the Clemson and her sister ships it is only the first period error of the teeth which is of interest. The second period would only produce synchronous response of the fundamental vibrations n_1 or n_2 at very low powers, since the revolutions per minute, of the propeller would then be $n_1/2$ or $n_2/2$; that is, in the neighbourhood of 200 r.p.m. A fourth period vibration n_3 would be excited by the fourth period tooth error near $1{,}658/4 = 414{\cdot}5$ r.p.m. of the starboard propeller, or $1{,}642/4 = 410{\cdot}5$ r.p.m. of the port propeller. But for so quick vibrations the rate of damping is certainly under-estimated because the nodes are now very near the turbine rotors and propeller, which therefore participate very slightly in the vibration and absorb little energy. The gear wheel, well removed from the nodes, vibrates much more and the absorption of energy by the friction of the teeth will be, relatively, much more important in this case; viscosity of the metal of the shafts will also have risen to be a larger factor. Also, inspection of Fig. 2 shows that the amplitude of fourth period tooth error is much less than that of the first period. However, had one of these main gear wheels had a serious fourth period error considerable vibration might have been excited. Calculations show, however, as one would expect, that the range of propeller speed over which these fast vibrations would be sensibly excited is extremely narrow. Apparently, a change of two revolutions of propeller, from exact synchronism would make them practically disappear.

Stresses Induced in Clemson's Gear.—Curve D, Fig. 2, shows an angular amplitude of the first period error to be very near 1/20,000 radian. This is the value assumed in the vibration stresses noted below. In Table II, I give only the worst cases calculated; except that, for the starboard gears, I add the results for 363 r.p.m. and 379 r.p.m., equally removed from exactly the synchronism of $n_1 = 371$.

Fig. 3.



(= N_H) the calculation gives the ratio of amplitude of vibration of the high-pressure rotor to that of its pinion as 102. The corresponding figure for the low-pressure rotor and pinion at 294 r.p.m. (= N_L) is 178.

I think the obvious conclusions from the foregoing is that, with reasonably well-cut gears, the Clemson and her sister ships should run smoothly at all speeds. This was notably the case. Also, there were so many synchronising speeds within their range of speed that it is not probable that other ships would be more likely to vibrate where elastic shafts are interposed between the rotors and pinions; that is, that the introduction of these elastic shafts without tuning is a safe arrangement. None of the great number of marine floating-frame gears fitted have shown any noticeable evidence of torsional vibration. But it is also obvious, as experience (especially with rigid gears) has amply shown, that gears must be most carefully cut.

Effect of Tuning.—Suppose there is a gear driven by only one pinion; that is, in Fig. 4, the gear G is driven only by the pinion P_1, actuated through an elastic shaft by the rotor R_1. If G revolved uniformly and its teeth had an amplitude of error of any period of $\frac{1}{20{,}000}$ radian, the resulting amplitude of vibration of the pinion would be greater than this in proportion to the ratio of reduction. For instance: In the case of the Clemson this ratio was originally 6·7.* Thus the amplitude of angular vibration induced in the pinion P_1 would be $\frac{6{\cdot}7}{20{,}000}$ radian. If P_1 and R_1 were Clemson's high pressure, and the speed of G were 442 r.p.m., we have the first period tooth error exciting the "exceptional vibration," and an amplitude of $R_1 = 102$ times that of $P_1 = \frac{6{\cdot}7 \times 102}{20{,}000}$ radian $= 0{\cdot}03417$ radian, or just under 2 deg. Such a vibration of R_1 would be very serious. But with only one pinion actuating the gear, such forces would set up a corresponding vibration of G, so timed as to very greatly diminish the effect of the first period error of the teeth. So exact was this compensation in the calculation, for the Clemson's high-pressure turbine alone in place, that the amplitude of vibration of R_1 was reduced to 0 deg. − 0 min. − 56 sec., and the vibration stress in the elastic shaft to 123 lb. per square inch.

The case is very different when there are two or more pinions, if these and their elastic shafts and turbine rotors are substantially identical or elastically equivalent, and running at the speed of the "exceptional vibration." For instance, in Fig. 4, suppose P_3 and R_3 absent, so that gear G is actuated at uniform speed by two pinions, P_1, P_2, placed opposite, or 180 deg. apart; also that these pinions, their elastic shafts, and rotors are of the same design and material. G has a first period tooth error and is running much under the speed which would give the "exceptional vibration," say, at 20 r.p.m. The whole mechanism will move as if rigid. On the rotations, shown in direction by arrows a, a_1 a_2, will be superimposed a vibration due to the tooth error of G, P_1 and R_1 will reach the maximum left-handed vibratory displacement, as indicated by the arrow V_1, at practically the same instant. They will then be in advance, by a whole amplitude, of the position they would have had if there had been no tooth error, since the arrows a_1, V_1, are similarly directed. At this same instant P_2 and R_2 will reach their maximum right-handed vibratory displacement, since the first period tooth error passes through half a cycle in one-half circumference of G. They will, therefore, be behind the position for no tooth error by a whole amplitude, since the arrows a_2, V_2, are oppositely directed. Thus, at the instant supposed the tooth pressure due to vibration exerted by both P_1 and P_2 on G is a maximum downward, as indicated by the arrows F_1, F_2. F_1 tends to accelerate G and F_2 to retard it by the same amount, as the rotors, &c., on the two sides are identical. F_1 and F_2 have a simple harmonic variation of the same period as the pinion vibration, and in half a cycle they will be directed upward; at all times they will be equal and similarly directed. G would, therefore, rotate uniformly, as supposed.

If, again, G is running considerably faster than the speed of the "exceptional vibration," the angular epochs of vibration of the pinion and its rotor would, as is well known, differ by 180 deg. As the rotor has always much greater moment of inertia than the pinion, the direction of the forces F_1, F_2, would be reversed from that shown in Fig. 4. Otherwise the case is unchanged and G would rotate uniformly.

At the exact speed of the "exceptional vibration"

TABLE II.

STARBOARD OR PORT.		STARBOARD.								PORT.			
R.P.M. of propeller and speed of vibration		n_1						N_H		n_1		N_H	
		363		371		379		442		363		442	
Total horse power		17,354		18,316		19,310		28,353		17,354		28,353	
Stress in elastic shaft. Lb. per sq. in.	From mean torque	10,859		11,213		11,573		14,571		10,859		14,571	
	High-pressure or low-pressure ..	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.	H.P.	L.P.
	From vibration	2,525	2,750	6,574	7,152	3,592	3,903	513	533	2,145	2,222	532	533
	Total	13,384	13,609	17,787	18,365	15,165	15,476	15,084	15,104	13,004	13,081	15,103	15,104

The stresses for n_2 and N_L are lower than those given, the vibration stresses in the elastic shafts being:—

TABLE III.

—	Starboard.		Port.	
	H.P. Shaft.	L.P. Shaft.	H.P. Shaft.	L.P. Shaft.
n_2	465		392	
Vibration stress	437	429	1,733	1,721
N_L	294		294	
Vibration stress	236	256	236	255

n_3 would give a considerable rise of stress from the fourth period vibration, especially in the port gear, if energy was absorbed by the propeller and turbine only. But, as already explained, these are feeble agents in this case and the friction of the teeth, of which no account has been taken, is important. Thus it is seen that in no case do the vibration stresses approach those which would produce hammering, and only in the immediate neighbourhood of 371 r.p.m. is there more than what could be called a slight rise of stress.

I wish it to be particularly noted, in view of results still to be given, that for N_H the rise of stress is very small. The speed is that of the "exceptional vibration" for the high pressure elastic shaft, but the main gear wheel is forced into vibration and communicates it to the low-pressure pinion and rotor, producing a slightly greater stress in the low-pressure elastic shaft.

It is of great interest to observe that for 442 r.p.m.

* *Virtual Node.*—When vibrating at the fundamental speed it may occur that the propeller and main gear wheel pass through the position of rest in the same direction. In that case there is, obviously, no node on the propeller shaft. But it will also appear that the angular amplitude of the propeller vibration is greater than that of the gear wheel; and if an extension of the shaft forward of the gear wheel be drawn, continuing the same rate of twist as the actual shaft has at any moment, a section will be reached where the twist is always zero. This is what I mean here by the "virtual node."

* Journal of the American Society of Naval Engineers, vol. xiv, page 754.

* The original pinions had long addendum teeth and, later, new pinions were made with one added tooth to get rid of this objectionable feature. The ratio of reduction was thus slightly reduced. In my calculations 6·7 is used.

the vibration of the rotor would lag one-quarter period behind that of the pinion, which would still leave the forces, F_1, F_2, equal and similarly directed at all times, and G would rotate uniformly. The same can be shown to be true in any case intermediate to those stated above, but it would be tedious to follow the action.

Hence, at all speeds, the first period error of the teeth would (unlike the result in the case of the single pinion, considered above) produce its full effect in vibrating the pinions; and near the speed of the "exceptional vibration" the great amplification of amplitude of the induced vibration of the rotor over that of the pinion would produce severe stresses in the elastic shafts, unless the tooth errors were less than there is any reason to hope for.

The stresses in the elastic shafts for the Clemson, supposing $\frac{1}{20,000}$ radian amplitude of first period error and the low-pressure turbine replaced by one dentical with the high pressure are, at 442 r.p.m. of G :—

	Lb. per Sq. In.
From mean torque	14,571
From vibration	15,149
Total	29,720

This case must be avoided. If P_1 and P_2 are of different pitch diameters, the action would be modified, as G would now participate in the vibration. The case is even more dangerous than the foregoing, for the vibration of G would be principally controlled by that pinion exerting the greater vibrational tooth pressure, and for it the vibration would be so timed as to partly compensate the tooth error, as was so completely done in the case of the single pinion. But this vibration of G would correspondingly add to the tooth error for the other pinion and still further raise the stress in its elastic shaft.

In nodal drive the two rotors are tuned, but they may be of different moments of inertia. In that case the forces F_1, F_2, will not usually be equal, and again G will participate in the vibration, raising the stress in one of the elastic shafts.* In nodal drive the "exceptional vibration" of the propeller is also made equal to that of the rotors and that, if accomplished, possibly may make the whole system still more sensitive to vibration of this periodicity. I have not yet calculated this case.

But it should be noted that in order to calculate the "exceptional vibration" for the propeller it is necessary to increase the actual moment of inertia of the propeller by an amount that it is impossible to predict exactly. In Mr. Frahm's investigation it varied from 20 per cent. to 32 per cent.—quite a wide range. If the wrong percentage is guessed the node will not occur at the gear wheel, which will consequently participate in the vibration and, almost certainly, increase the stress in one of the elastic shafts.

G would also participate in the vibration if P_1 and P_2 were less than 180 deg. apart. This would raise the stress in one of the elastic shafts unless the pinions were at only a small angular distance from one another—a case practically impossible, or most unlikely to occur—when they act nearly together and approximate to the case of a single pinion given above.

I will now take the case of a four-pinion gear such as was constructed recently by the Westinghouse Company for the Japanese Government, driven by two high-pressure and two low-pressure turbines. But the stresses given below are founded on the data of the Clemson, properly increasing the moment of inertia of the propeller and diameter of the propeller shafting, as the power is doubled, and also slightly increasing the moment of inertia of the main gear wheel.

Fig. 5 shows the most probable arrangement where the two high-pressure turbines are uppermost and the two low-pressure below. The most natural thing would be to make A and B duplicates and also C and D. The centres through the gear to each turbine is at 45 deg. to the vertical. G is shown turning right-handed. From what has been said above it is evident that if the two high-pressure turbines, A and B, were placed exactly on opposite sides of the gear wheel, that is 180 deg. apart, and also the two low pressure, C and D, 180 deg. apart, the gear wheel G would revolve uniformly even if there were a first period error of the teeth. As they are not so placed G will participate in the vibration and the elastic shafts will be unequally stressed. A and B are supposed to be exact twins so that $N_H = 442$, as before and N_L, for C and D = 294. At 442 r.p.m. of G the horse-power is 56,706, equally divided among the four turbines. The stress in the elastic shafts from mean torque is 14,571 lb. per square inch. The vibration stresses are :—

TABLE IV.

	Lb. per Sq. In.
Propeller shaft	4·2
Elastic shaft A	10,497
Elastic shaft B	23,850
Elastic shaft C	423
Elastic shaft D	192

Thus for an amplitude of first period error of the teeth much smaller than supposed, those of pinion B would commence to lift off and a destructive hammering be set up.

* In the case supposed here the node on the propeller shaft is not exactly at the gear wheel and consequently the propeller is not exactly "in tune." I should add that, as I understand Dr. Smith's paper, the node is produced at the gear wheel by similarly directed vibrations of R_1 and R_2 balancing the oppositely-directed vibration of the propeller; that is, the arrows V_1 and V_2, Fig. 4, would both point right-handed when the vibrational rotation of the propeller is left-handed. The state of vibration set up by the tooth errors is therefore, as shown above, quite different from that contemplated in nodal drive.

Effect of Discord.—The effect of putting all the turbines out of tune is most remarkable. This, from equation (3) can obviously be done in four ways :—

(1) By changing J, or the diameter of the elastic shaft.
(2) By changing L, or its length.
(3) By changing I, the moment of inertia of the rotor.
(4) By changing μ, or the material of which the elastic shaft is made.

The simplest way of attaining the result is by changing J, as this varies as the fourth power of the shaft diameter; thus N varies as the square of the diameter, while it varies only as $\sqrt{\mu/L\,I}$. It will not often be convenient to change I or μ.

I will suppose here that the diameter of one high-pressure and one low-pressure elastic shaft is increased 10 per cent. We then have four speeds for the "exceptional vibration," and therefore four speeds of G at which great magnification of a rotor vibration over that of its pinion will take place :—

High-pressure shaft increased 10 per cent. = $442 \times 1{\cdot}21 = 535$ r.p.m.
High-pressure shaft not increased = 442 r.p.m.
Low-pressure shaft increased 10 per cent. = $294 \times 1{\cdot}21 = 356$ r.p.m.
Low-pressure shaft not increased = 294 r.p.m.

These periods are well separated. I only calculated the values for 442 r.p.m. From this we can see the effect

Fig. 4.

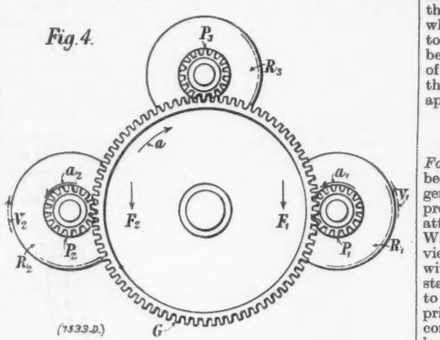
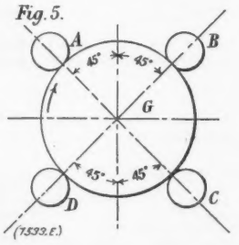


Fig. 5.



of the change by comparing the stresses with those given in Table IV.

There are obviously four cases :—

Case I.—Elastic shafts B and D increased 10 per cent.; G revolves right-handed as shown by arrow.

Case II.—Elastic shafts B and D increased; G revolves left-handed.

Case III.—Shafts B and C increased; G revolves right-handed.

Case IV.—Shafts B and C increased; G revolves left-handed.

I will only give the stresses for Case I, which proved to be very slightly the worst. As before the stresses are in pounds per square inch.

TABLE V.

Elastic shaft	A	B	C	D
From mean torque ..	14,571	10,947	14,571	10,947
Maximum vibratory stress	1,315	468	514	648
Maximum total stress	15,886	11,415	15,085	11,595

Table IV. shows that some device for reducing vibratory stress is necessary, and Table V shows that the one proposed here is entirely effective.*

In the above illustrations I have used almost exclusively the first period error of the teeth. But the second or any other period might have been used. As the second period error goes through half a cycle in a quadrant of G the combination of P_1 and P_3, Fig. 4, when considering this period, is equivalent to that of P_1 and P_2 when considering first period; and so on with the other periods. For instance, the combination of P_1 and P_2, with a second period error, is equivalent to a single pinion gear, since the pinions are 180 deg. apart and 180 deg. $\times$ 2 = 360 deg.

Conclusion.—In a "tuned" two-pinion gear there will obviously be one dangerous speed for each period of tooth error; and in a four-pinion gear there will be two dangerous speeds for each such error. In the nodal drive, while the number of synchronising speeds is greatly reduced, it is made extraordinarily sensitive to the "exceptional period." If danger is to be avoided this period would have to occur at a very low power; but that, I think, so far at least as tuning the propeller vibration is concerned, would not usually be possible—the "exceptional vibration" of the Clemson's propeller is about 370 r.p.m. for the port and 447 for the starboard, and her shafting is long. If, for instance, in the case of a ship with the machinery aft and, consequently, the shafting short, the "exceptional vibration" is put high—above full speed of the propeller—the second or higher period errors of the teeth would become important.

On the other hand, Table II shows that the Clemson is very insensitive to all but one speed, 371 r.p.m. of the starboard propeller, and not dangerously sensitive to that. I repeat the conclusion that the introduction of elastic shafts, "out of tune," is a perfect protection against damage through vibration, and this is enforced by the fact that neither in the Clemson and her 33 sister ships, nor in any one of the other ships fitted with floating-frame gears and elastic shafts (between two and three hundred) has there been the slightest noticeable indication of the presence of torsional vibration.

I have dealt entirely with the effect of defective tooth cutting, but, obviously, the variable resistance experienced by the propeller supplies excitation of various periods. We know little of the law of variation as the propeller revolves, and it is very different in different cases; it is, therefore, more difficult to make probable assumption on which to found analysis. However, a system sensitive to one mode of torsional excitation and one period will be sensitive also to any other mode of such excitation of the same period, unless applied at a node; and, on the other hand, if insensitive when the excitation is not applied at a node it will always be insensitive.

* It is not, I hope, improper to state that I have applied for patents in the United States, Japan and Britain, broadly covering the proposals indicated above.

ELECTRICITY FROM PEAT.—According to the *Danish Foreign Office Journal*, a technical committee which has been considering the practicability and profitableness of generating electricity with the use of peat as a fuel has presented a report in which, on the strength of results attained at a temporary plant erected in the so-called Wildbog ("Vildmosen") in Jutland, it expresses the view that with the cost of labour now prevailing, and with the use of peat from normal bogs at electricity stations equipped with turbines, it would be possible to compete with stations using coal as fuel, even if the price of coal went down to 25 kroner per ton. The committee regards the technical difficulties as having been overcome, and recommends that State support should be granted to aid private initiative in the establishment of a permanent generating station equipped for the consumption of peat.

THE PREVENTION OF WASTE OF WATER.—The British Waterworks Association, 173, Rosebery-avenue, E.C. 1, has recently issued a draft, which has been submitted to the Ministry of Health for approval, of model bye-laws and regulations for the prevention of waste and misuse of water. With these are embodied specifications for standard water pipes and fittings. The whole is issued in pamphlet form at a cost of 5*s.* net. The present association was formed in 1919 when it took over the work of the Incorporated Joint Committee on Water Regulations. The latter body originated in 1904, and in 1908 issued, a model code of bye-laws and specifications which were subsequently re-issued and supplemented. Since these appeared various changes have made it advisable to review the whole subject, and the present draft is the outcome of the work extending over some time. New draft specifications were drawn up in 1920, and after being revised and re-arranged to meet criticism, in 1921 and 1922, and are now issued in amended form with the code of bye-laws and regulations. The work has received a very considerable measure of support, and as the advantages of uniformity in these matters throughout the country are obvious, it is to be hoped the model code will commend itself to the authorities concerned. They will, we are sure, be found to afford useful guidance and assistance in numerous instances.

TRADE MARKS IN CHINA.—Foreigners in China are guaranteed protection in the use of their trade marks against fellow countrymen, in their own consulates, and against other nationals as provided by international treaties, says the Chinese Government Bureau of Economic Information. Under the system of extra-territoriality obtaining in China, reciprocal arrangements have been entered into between Great Britain, Belgium, Denmark, France, Germany, Italy, Portugal, Netherlands and the United States by which trade marks are protected when registered in the country in whose courts in China protection is sought. These is no reciprocal arrangement between Japan and Great Britain, although some arrangement has been made between Japan and the United States. Treaties exist between China and the United States regarding the protection of American Trade Marks in China. However, all these provisions, especially as between foreigners of different nationalities in China, are of uncertain value. In the Shanghai Mixed Court Report for September, 1922, in the matter of the application of Burkhardt, Amidani and Co. for the registration of the silk-reeling invention "Hofer," the judgment was given that "There are no provisions in China for the protection and registration of foreign patents and the court has no power to grant the declaration asked for." The Ministry of Agriculture and Commerce have recently opened an office in Shanghai for the registration of trade marks. The office is located at 25, Jinkee-road.